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Morphological Development
From the Beginner to the Proficient Reader

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Morphological Development: From the Beginner to the Proficient Reader

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Author's Declaration

The work presented in this thesis has been completed solely by the author under the supervision of Dr Helen Breadmore, Dr Anna Cunningham and Professor Lynn Clouder. This work has not been submitted for any other degree or qualification.

Abstract

There is now a vast amount of evidence that morphological knowledge contributes to literacy development. Yet very few studies have examined morphological awareness in children as young as 4-years old, perhaps due to their cognitive immaturity. This is a crucial first step in determining whether morphological awareness in oral language contributes to later literacy development. Prior lack of evidence of morphological awareness in this age group may not be due to its absence but to task demands. Therefore, in chapter 2, a novel dynamic morphological awareness task was developed and found to be a feasible, reliable and valid tool, providing in-depth information about beginner readers' morphological awareness. This assessment was applied in chapter 3, using a longitudinal paradigm to illustrate how morphological awareness contributed to literacy measures a year later. In this first year of education, morphological awareness in oral language was found to contribute to later reading comprehension, even after accounting for the specific phonological component of the task. However, morphological awareness was not a longitudinal predictor of word reading or spelling. Next, from morphological awareness in oral language, morphological development in the reading processes of older children (7-12 years old) and adults was examined. Due to the multidimensional nature of morphological development, understanding about morphological structure has been shown to be important for reading processes. However, past studies have generally investigated this in single word reading. To examine morphological development during sentence reading, two eye-tracking paradigms were employed to assess morphological processing of children and adults in a cross-sectional design. In chapter 4, evidence for morphological decomposition was examined by manipulating the base and surface frequency of the target word. The results revealed surface frequency effects for both adults and children. Base frequency effects were found for

children, but not adults. This suggests that children carried out decomposition to access morphologically complex words whilst adults were able to process the whole word without decomposition. Chapter 5 employed the boundary paradigm to investigate the contributions of orthographic and morphological information in priming a morphologically complex word. Whilst children showed an orthographic preview benefit, adults showed a morphological preview benefit. These findings suggest that skilled reading highlights the morphological structure of words. The discrepancy in findings between chapters 4 and 5 may be due to different aspects of morphological processing. While the foveal processes in chapter 4 reflect decomposition, the parafoveal processes in chapter 5 might reflect a dimension of morphological analysis which has not yet developed in children. In conclusion, the current thesis has contributed to understanding about the development of morphology from the oral language of beginner readers to reading in intermediate and skilled readers. Morphological knowledge is multidimensional and contributes differentially across literacy development but remains important throughout.

1 Literature Review

1.1 Introduction

Literacy refers to the ability to use skills at the word level including word reading and spelling, and at the text-level including comprehension (Breadmore et al., 2019). This ability is fundamental, and the lack thereof can severely restrict a child's potential in life. Literacy development is the progression of literacy skills. Monitoring literacy developmental is necessary to understand how children acquire processes in reading and writing.

As a child enters formal schooling for the first time, little else is more important than their literacy acquisition and development. Reading and writing eventually become essential tools for education; switching from learning to read to reading to learn. At the early stage of literacy instruction, aged 4-5, the child experiences formal literacy instruction for the first time and the primary goal is for them to be successful.

Yet, even at this early stage, there are clear individual differences in the literacy skills of young children (Raz & Bryant, 1990). It is important to explore these differences for at least two reasons: To understand which literacy interventions might be most effective in atypical literacy development, and which skills might contribute more generally to literacy acquisition. A clear place to start would be in pre-cursive language skills. Firstly, children are relatively proficient in their use of oral language by the time they learn to read (Fowler, 2011). Secondly, oral language mirrors written language very closely. It seems logical then that precursory skills involved in language ability are key determinants in the acquisition of skilled literacy.

Morphological awareness is one such language-based skill that contributes to literacy development. For clarity, I define the term morphological awareness, on the basis of past research. Carlisle and Feldman (1995) define morphological awareness as "*children's* *conscious awareness of morphemic structure of words and their ability to explicitly reflect on and manipulate that structure*" (p. 194). This is one of the most commonly cited definitions of morphological awareness in the field and several other established researchers have adopted a similar definition (Kirby et al., 2012). In line with this, Kuo and Anderson (2006) describes morphological awareness as "*the ability to reflect upon and manipulate morphemes and employ word formation rules in one's language*" (p. 161). Similarly, Kieffer and Lesaux (2012) state that morphological awareness concerns "*word-level meaning and involves procedural knowledge about words and the rules that govern their formation*" (p. 25). Therefore, for the purpose of this thesis, morphological awareness may be defined as children's conscious awareness of the minimal units of meaning and their ability to explicitly manipulate morphemes, employing word formation rules in spoken language.

Due to the myriad of terms ascribed to morphological awareness and its various related constructs, the following paragraph will be used to define some of the key concepts that will be operationalized in this thesis. Although the definitions of several of these terms are arguable, it is important, at the very least, to have a shared understanding of how these terms are conceptualized here. Morphology, broadly, is the study of units of meaning within words (Haspelmath & Sims, 2013). Morphemes are the smallest units of meaning within words. For example, the word *wonderful* contains the morphemes *wonder* and *-ful*. Whereas morphologically complex or multimorphemic words contain several such units, morphologically simple words contain only one morpheme (e.g., *bath*) (Niswander et al., 2000). Morphological learning and knowledge refer to the acquisition of information about the internal structure of words (Hare & Elman, 1995; Marquis & Shi, 2012). Whilst morphological awareness is reserved for more general morphological understanding, morphological analysis and decoding refer to the actual process of scrutinising morphemes within words (Anglin et al., 1993). This is done, presumably, with a view to aiding in understanding, spelling and pronouncing morphologically complex words. This brings us then to morphological processing. Morphological processing refers to the real-time derivation of meaning from morphologically complex words (Feldman, 2013; Schreuder & Baayen, 1995).

Morphological awareness provides literacy cues at both the word-level and the text-level. This is increasingly called the multidimensionality of morphological knowledge whereby morphemes integrate information about form (phonology and orthography) and semantics (Goodwin et al., 2021; Levesque et al., 2021). For example, at the word-level, the ability to decompose a word into its constituent morphemes might enable a child to not only spell and decipher the word meaning but also use grammatical cues within the morphemic structure to understand the sentence. Further, at the text-level, morphologically complex words are generally the longer, less frequent and more complex words in a sentence, and thus if a child is able to decipher these words, then they are more likely to ‘crack’ the sentence.

Further, some types of morphology, particularly tense morphology (e.g., *walk-ed*), drive the syntactic form (structure and arrangement of words in a sentence) of many types of sentences. Morphological awareness taps various other literacy skills. For example, the skills used to isolate morphemes into separate units might be the ones used to isolate phonemes in phonological awareness. The ability to break down a less frequent morphologically complex word into more manageable and familiar units of meaning (morphemes) might contribute to increased vocabulary.

Finally, using morphological, instead of phonological based principles to spell words might contribute to accurate spelling. Take for example the word *electricity* comprised of the morphemes *electric* and *ity*. Knowledge of each of these morphemes would aid a child to correctly spell the word. Yet, writing the word according to phonological mappings, would lead to erroneous spelling. Naturally then, morphological awareness has been described as an index for literacy (Carlisle & Feldman, 1995).

In the sections that follow, this literature review will firstly discuss language development. Next, key models of reading and comprehension which have been used to describe the processes used in literacy will be examined. Specifically, the aim is to assess how these models might predict the contribution of morphological awareness to literacy. Following this, the relationship between morphological awareness and pertinent literacy skills will be examined. Finally, there will be a discussion of the different aspects of morphology and the tasks that have been used to tap these.

1.2 Language and Literacy Development

The acquisition of oral language by typically developing children has been characterized as an effortless process, requiring no formal instruction (Rice, 1989). Although some children need to be taught to speak, for the vast majority language emerges spontaneously in response to everyday social communication (Rice, 1989). Further, the skill emerges at a relatively early age, with most children beginning to talk at approximately 12-18 months. In contrast, the mastery of literacy skills such as reading and writing, require concerted effort from the child and instruction from the teacher (Freeman & Freeman, 2004). Typically, the onset of reading occurs between 60-84 months and rarely before 36 months. In archaeology, this pattern is reflected as all societies engage with some form of oral language, yet written language has not been universally acquired. Indeed, certain accounts suggest that historically, oral language preceded written language (Schmandt-Besserat & Erard, 2008).

Written language skills encompass reading and writing (Shanahan et al., 2006). Reading involves the ability to recognise and pronounce single words and words within a sentence. Although children need to be taught to read, it is a relatively automatic process for adults who can recognize words quickly and effortlessly (Ehri, 1994). This process is called sight reading whereby visual perception of a word triggers immediate recognition and understanding of the word's meaning (LaBerge & Samuels, 1974). Decoding is another way to read and it refers to the process of transforming smaller units within words (usually graphemes or morphemes) into phonemes and blending these together. As discussed above, the mechanisms underlying reading are still not well understood and different theories have been offered and disputed. In order to elucidate the factors that contribute to reading development, researchers have investigated pre-cursive language skills.

Principally, phonological awareness has surfaced as a skill that is highly predictive of reading ability (Carroll et al., 2003; Kirby et al., 2012; Lyster et al., 2016; Stahl & Murray, 1994). Phonological awareness refers to sensitivity to the sound structure of words (Torgesen et al., 1994). Yet, vocabulary, orthographic awareness (awareness of the positioning of letters within words), and morphological awareness also contribute to skilled reading (Badian, 1995; Deacon & Kirby, 2004; Ricketts et al., 2007).

Reading comprehension refers to the child's derivation of meaning from the read text (McLaughlin, 2012). It is not simply their understanding of individual words; the child must develop a mental representation of the text. The point of writing texts is to convey a message and the point of reading is to construct meaning from that message. Thus, comprehension is the main objective of reading (Nation, 2000).

In literacy development studies, this has typically been measured using large-scale standardised assessments, such as the York Assessment of Reading for Comprehension, which require the child to read a text and then answer relevant questions (YARC; Snowling et al., 2009). Here there are issues to consider. For example, different reading comprehension assessments measure different aspects of comprehension and different score ranges. Colenbrander et al., (2016) found significant differences in two widely used comprehension tests: the Neale Analysis of Reading Ability (NARA) and the YARC. The NARA comprehension scores tapped decoding skills more than did the YARC scores, but the NARA passages spanned a wider range of difficulty. This resulted in 15-34% of the tested children receiving different diagnostic results. Other research has shown that different types of skills contribute more to comprehension of different levels of text. For example, higher order cognitive skills might contribute to comprehension of more complex texts whilst language skills such as semantic and syntactic awareness might contribute to less complex texts (Eason et al., 2012). Thus, this supports the notion that comprehension is a varied construct requiring several different types of underpinning skills. Yet, more research is needed to assess how pre-literate skills, particularly morphological awareness, contribute to reading comprehension.

Writing involves the ability to write and spell single words and words within a sentence. Arguably, the ability to write words is more complex, cognitively, than reading and requires even more skills (Breadmore et al., 2019). To read a word, recognition of the orthography is sufficient. In order to write the word with correct spelling, the orthography is not simply recognized, but recalled and recoded in the correct order. Among the contributing skills, phonological awareness, visual attention and grammar have garnered much of the support from evidence (Castiglioni-Spalten & Ehri, 2003; Muter et al., 2004; Plaza & Cohen, 2007).

More recently, morphological awareness has emerged as highly critical contributor to spelling development (Deacon et al., 2009). However, Rispens et al., (2008) found that whereas derivational morphology contributed to spelling in Grade 6 (mean age 12 years, 1 month), it did not for younger Grade 1 children (mean age 6 years, 11 months). Perhaps, other skills such as phonological awareness, and vocabulary contribute more at this younger age for simpler words. As children get older, they master simpler words and encounter more complex words. At this point, morphological awareness might become essential for spelling accuracy. In any case, further findings are necessary to clarify this.

Regarding the pattern of onset for these skills, two findings are important to note. Firstly, the four language systems (listening, speaking, reading, and writing) develop in overlapping and parallel waves beginning with the onset of speech perception (6-8 months), followed by the onset of speaking (12-18 months), then reading (36-84 months) and finally writing (Berninger, 2000; Jusczyk & Aslin, 1995). Although, these waves are not concrete stages, the onset of oral language generally precedes literacy skills (i.e., reading and writing) whilst the onset of reading generally precedes writing. Secondly, literacy skill has the potential to affect and be affected by oral language although the latter is more likely (Rice, 1989).

As expected, oral language skills in pre-school age children have a strong relationship with later literacy skills (Snow et al., 1995). While print skills are important, particularly in the earlier stages of learning to read, oral decontextualized language skills (e.g. narrative language) become increasingly helpful as reading becomes less of a decoding-based task and more of a comprehension based one (Snow et al., 1995). For example, older children are expected to use cues in complex texts to interpret their meaning; this higher level of interpretive comprehension is less bound to single word decoding than is literal comprehension (Simmons & Singleton, 2000). Further, while early phonological skill is closely linked to single word reading, it does not reliably predict reading comprehension (Roth et al., 2002). While phonological awareness and print skills correspond predictably to word reading and writing, semantic abilities contribute uniquely to reading comprehension (Roth et al., 2002; Snow et al., 1995).

With regards to spelling development, some researchers contend that it is word reading accuracy and not oral language skills that is important (McCarthy et al., 2012). It is argued that good spelling relies on knowledge of the correct orthographic ordering of letters in the form of phoneme-grapheme correspondences (Juel et al., 1986). It would seem then, that different aspects of oral language in pre-school children contribute separately to various aspects of literacy and language outcomes in school age children.

Finally, it is important to consider the developmental progression of reading. Ascribing any one rigid mechanism to reading and reading comprehension is problematic, because reading strategies change over the course of cognitive development and number of years in formal education amongst other factors. Reading strategies and skill levels can even vary dramatically across children within the same age group (Stuart & Coltheart, 1988). This is why it can be counter-productive to, for example, make general assumptions about the usefulness of higher -level skills such as morphological awareness for younger children's reading development.

1.2.1 The Morphological Pathways Framework

The Morphological Pathways Framework (MPF; Levesque et al., 2021) was developed due to a lack of inclusion of morphology in theories of literacy development; this, despite the mounting evidence for the role of morphology in literacy (Deacon & Kirby, 2004; Enderby et al., 2021; Kuo & Anderson, 2006). The MPF incorporates elements of the Reading Systems Framework (Perfetti & Stafura, 2014), which itself makes three claims about reading. First, reading uses linguistic knowledge, orthographic knowledge and general knowledge. Second, reading processes use these classes of knowledge individually and combinatorically. Third, these reading processes are supported by a cognitive system whilst being constrained by limited processing resources.

The MPF uses the principles of the Reading Systems Framework but extends its scope to include morphology and its role in reading processes (see figure 1). As previously mentioned, several studies have highlighted that morphology contributes to literacy development (Deacon & Kirby, 2004; Enderby et al., 2021; Kuo & Anderson, 2006). Yet no previous theory provided an account for the underpinning mechanisms through which morphology supports literacy. In the section that follows, the MPF will be examined, as the only defined theoretical framework, to highlight claims made about the role of morphology in literacy development. In so doing, key morphological processes-morphological awareness, morphological decoding, morphological decomposition, morphological processing and morphological analysis- will be defined, particularly within the context of the Morphological Pathways Framework.

The Morphological Pathways Framework incorporates three pathways through which morphological awareness influences reading, at both the level of word form (i.e., word reading) and meaning of connected text (i.e., reading comprehension); directly and through morphological decoding and morphological analysis.

Morphological decoding is the process by which morphemic units are used for reading, providing a pathway from Central Orthographic Processes to Lexical Representations. Morphological decoding is constrained to the word's orthographic structure whereby knowledge of morphemes allows for decomposition of morphologically complex words. Thus, morphological decoding is the use of morphological knowledge to read, and decomposition-separating words into their constituent morphemes-is the direct result of that process. Morphological analysis, on the other hand, is concerned with semantic knowledge of morphemes and allows the reader to access understanding of morphologically complex words.

The MPF further distinguishes between morphological processing and morphological awareness. The former is the process by which morphological analysis and decoding is used at input identification. The latter is the more general metalinguistic awareness of morphological regularities. This is important because word reading and reading comprehension do not exist in separate bubbles, but influence each other bi-directionally (Deacon et al., 2017). Moreover, morphology in its multidimensionality, subsumes features of various linguistic components including semantics, phonology, syntactics and orthography, all of which contribute to high quality lexical representation (Perfetti, 2007).

The Framework also addresses the distinction between the linguistic system and the orthographic systems and describes how these may be supported by morphology. Most importantly, the Framework provides a set of research-based expectations which are specific to morphological development, and which may be used by both researchers and educators. In particular, for researchers, it can be used to test certain assumptions about morphology with greater specificity.

Figure 1.

The Morphological Pathways Framework

Note. Figure taken from Levesque et al., (2021)

1.2.2 Ehri's Theory of Reading Development

Ehri's theory of reading development incorporates notions regarding language units and reading strategies across different phases of learning (Ehri, 2005). Although general ideas are given about the timeframe for each phase, the theory stipulates that each previous phase is not required for the acquisition of the subsequent phase. Thus, phase development allows for flexible guidelines regarding literacy acquisition. This is in line with previous evidence regarding reading development which has generally found that the process of reading acquisition can vary due to factors such as individual differences (Share et al., 1984) and reading experience (Cunningham & Stanovich, 1997).

Ehri's four phases each signify progressive advances in children's reading: Pre-alphabetic (pre-school), partial alphabetic (start of school), full alphabetic (first two years of school) and consolidated alphabetic (third year of school) (Ehri & McCormick, 1998; Ehri & Soffer, 1999; Ehri, 1994). The pre-alphabetic phase is characterised by a basic form of sight word identification. During this phase children have not yet learned about the alphabetic system; therefore, they can only identify words according to coarse visual features (e.g., 'eyes' in the middle of the word *good*). Children at this phase are essentially illiterate.

During the partial-alphabetic stage, children learn the names and sounds of letters and use these in an effort to read words. However, they do not have full knowledge of the alphabetic system, are unable to segment all of a word's phonemes and have difficulty forming connections between some letters and sounds (Johnston et al., 1996).

Subsequently, children attain the full alphabetic phase when they can read words using complete connections between letters and pronunciations (i.e., grapheme-phoneme correspondence). Due to their fuller understanding of the alphabetic system, they are able to decode unfamiliar words.

Finally, during the consolidated phase, readers are able to access familiar or sight words from memory. Moreover, less familiar words may be broken down into larger 'chunks' such as morphemes or syllables.

As previously stated, Ehri notes that there might not necessarily be clear and defined progression from one phase to the next. This seems plausible and is corroborated by previous research (e.g., Stuart & Coltheart, 1988). Yet, there may still be some inconsistencies (Beech, 2005). For example, Ehri (2005) does not state whether phases may overlap so that children are in two or more phases at once. These become particularly emphasised when considering morphological development.

According to Ehri's phases, children only move beyond segmentation by phonemes in the final consolidated phase. Yet, much younger children have been found to consolidate morphemes whilst still grappling with the alphabetic system. Casalis and Louis-Alexandre (2000) found that French-speaking novice readers (mean age=5 years, 8 months) had poorer phonemic segmentation (approximately 19% correct) than morphemic segmentation (approximately 50% correct). In English, children of a similar age have been found to be fairly accurate at forming regular inflections (Berko, 1958). Moreover, morphological training has been shown to improve word identification (Nunes et al., 2003).

Also, morphological awareness has been shown to have a longer 'tail' than other literacy skills, emerging earlier than is often stated and developing for longer, often into adolescence (Dawson et al., 2018). Thus, restricting its development into the consolidated phase (which extends over the second and third years of formal schooling) may not be appropriate.

Notably, the use of morphemes in morphological decoding (Singson et al., 2000) signals its importance beyond longer letter strings or a larger grain size. Morphemes are distinct from other letter strings in that they carry multidimensional cues, including semantics, grammar and orthography. Several studies have found that morphological decoding explicitly supports literacy development (e.g., Deacon et al., 2017; Enderby et al., 2021) perhaps through an increased quality of lexical representations. The Morphological

Pathways Framework expounds on this as the use of morphological decoding to access lexical representations (Levesque et al., 2021).

In any case, Ehri (2005) has acknowledged that the boundaries of the different phases are to be viewed as fuzzy and not clear-cut. With this caveat in mind, Ehri’s phases of reading development is an invaluable guide for researchers examining reading development. In the next section, I discuss some of the models which might account for the role of morphological development in literacy acquisition.

1.3 Models of Word Reading

1.3.1 Dual-Route Model

Arguably, one of the most impactful models is the dual-route model of reading. This model has existed as a theoretical basis for reading for almost a century beginning with De Saussure (1922). Coltheart (1985) developed and substantiated the framework using computational models and experimental data. It was also at this point that the lexical and non-lexical reading routes were defined. The lexical route is more automatic and refers to words that are accessed from the mental lexicon via word pronunciations and spellings while the non-lexical route makes use of grapheme-phoneme correspondences to access word meanings (Coltheart, 2005). New words can be decoded using the non-lexical route, and after several exposures to reading a word, meaning can be accessed through the lexical route. This is known as a ‘self-teaching’ mechanism (Share, 1995).

Studies measuring frequency effects in words have been instrumental in garnering support for the dual-route model (Coltheart & Rastle, 1994). If complex words are accessed by their constituent morphemes then base frequency effects are shown Through these and studies using other variables (e.g., homophone and non-words), more facts about reading may be explained by the dual-route model than other single-route models (e.g., parallel-distributed-processing, Seidenberg & McClelland, 1989). For example, Weekes (1997) found that longer non-words produced significantly longer reading time latencies than shorter non-words. In contrast, familiar words were read at the same speed, regardless of word length. This suggests that readers use grapheme-phoneme correspondence in the non-lexical route to decipher unfamiliar words but access the quicker lexical process for familiar words.

1.3.2 Grain Size Theory

Thus, the spelling-to-sound mappings involved in the alphabetic principle are important in deciphering unfamiliar words, yet researchers have found that there is even more to the story. Paap and Noel (1991) shared in the consensus view that the strongest form of the dual-theory model should involve units larger than graphemes. If individuals can access words whole, and via their phonemes, then it follows that words may also be accessed at other grain sizes available in the language system.

Further cementing this idea, Ziegler and Goswami (2005) introduced the psycholinguistic grain size theory. According to this theory concepts such as the alphabetic principle form basic building blocks for later skilled reading (Ziegler & Goswami, 2005). Mastery of the decoding of smaller grain sizes such as phonemes may be seen to pave the way for the decoding of larger grain sizes such as morphemes, wherein the most efficient reading strategy involves whole word access (Goswami & Ziegler, 2006).

More recently however, Grainger and Ziegler (2011) argue against competing routes, in favour of a multiple-route model allowing several different inter-dependent mechanisms to operate in concert for print to meaning conversion. In this multiple-route approach to orthographic processing, coarse-grained and fine-grained orthographic processes are both applied to word recognition. Whilst the former provides a global representation of the relevant phonemes, the latter fine-tunes this representation to provide information such as letter ordering.

According to this view, different types of orthographic code perform different functions. One such orthographic code is linked to morpho-orthographic segmentation by way of a mechanism involving affix detection. This mechanism occurs via the fine-grained route since the detection of affixes requires precise letter-position coding. Highlighting the salience of affix detection, seminal experiments have found that pseudo morphologically complex primes (e.g., *corn-corner*) and genuine morphologically complex primes (e.g. *worker-work*) show significantly greater facilitation than primes containing a stem and a non-suffix ending (e.g., *scandal-scan*) for both adults (Rastle et al., 2004) and adolescents (Dawson et al., 2021).

However, Dawson et al., (2018) found that this pattern is different for children (7-9 years old) and younger adolescents (12-13 years old). Using a timed lexical decision task across adults to investigate morphological decomposition across adolescents and children, they compared accuracy and reaction time to pseudomorphemic nonwords (e.g., earis*t*), and control nonwords (e.g., *earilt*). While adults and adolescents were slower to reject pseudomorphemic nonwords than control nonwords, children were not. These results highlight key differences in sensitivity to morphological structure that perhaps change between childhood and adolescence. The current thesis further examined this issue while studying eye-movements for deeper analysis of morphological processing during reading in children and adults.

1.4 Models of Word Reading and Reading comprehension

Notably absent from the models discussed above are assumptions about mechanisms underpinning not only word reading, but also reading comprehension. Clearly, if a child can identify individual words but not understand what they are reading, they cannot be described as literate. Gough and Tunmer (1986) argued that reading is the product of word decoding and comprehension (R=D X C). Thus, if any of the factors are null, reading too will be null.

Yet, there appears to be a lack of discussion around processes in literacy acquisition that go beyond phonics-based reading instruction (Castles et al., 2018). This is particularly salient since evidence has shown that the predominantly phonics-based skills that support word decoding are not necessarily the same skills that support reading comprehension (Oakhill et al., 2003). The models that follow incorporate reading comprehension as a key component of reading thereby reflecting a more complete picture of its development.

1.4.1 Simple View of Reading

The simple view of reading contends that two skills, linguistic comprehension and decoding, are necessary for skilled reading (Hoover & Gough, 1990). Here, linguistic comprehension refers to the full set of linguistic skills such as parsing, bridging, and discourse building (Hoover & Gough, 1990). Decoding refers to the ability of the reader to transform graphic shapes into linguistic form. The simple view holds that both components are equally important for reading. Further, it is argued that both parts are separable and are supported by different cognitive abilities (Pazzaglia et al., 1993). Evidence for this comes predominantly from studies involving individuals with dissociated linguistic skills.

If reading may be explained separately by linguistic comprehension and decoding skills, it follows then that there should be three types of reading disability: Impairments in comprehension but spared decoding, impairments in decoding but spared comprehension, and impairments in both (Gough & Tunmer, 1986). The first of the these refers to hyperlexics, or poor comprehenders (Nation et al., 1999), children with impaired language ability who demonstrate surprising advanced word recognition skills (Healy, 1982). It is hypothesised that this is due to specific preserved decoding skill in the presence of general linguistic disability.

Evidence for the second of these comes from individuals with dyslexia. Developmental dyslexia characterizes individuals that have problems with reading despite sufficient intelligence, motivation and schooling for skilled reading (Shaywitz, 1998). A wealth of studies has found that children with dyslexia possess significantly poorer decoding skills than typically developing children (see Vellutino et al., 2004 for a review).

The third disability is usually demonstrated by common reading disability- specifically referred to as common reading disability because this third case is far more common than the previous two (Gough & Tunmer, 1986).

Indeed, a key argument against the simple view of reading is that these deficits, linguistic comprehension and decoding, are found together far more commonly than separately (Shankweiler et al., 1999). If these skills contribute separately to reading disability, should the vast majority of cases of reading disability encompass them both together?

Yet, there might be a simple explanation for this finding. The already poor skills in one domain might negatively impact the “preserved” domain. For example, a child with poor decoding skills might struggle to comprehend linguistic information due to their inability to identify single words. Another problem is that both the simple view of reading (e.g., Juel, 1988) and the phonological deficit hypothesis (e.g., Hagtvet, 2003) cite poor decoding leading to reading disability as evidence for each of their respective theories. Proponents of the latter theory often interpret the decoding disability in individuals with Dyslexia as uniquely phonological (e.g., Hagtvet, 2003). This, then, would support evidence for a unique phonological skill underpinning reading ability.

An interesting question then is how children with Dyslexia process larger chunks such as morphemes. Casalis et al., (2004) compared the performance of dyslexic and reading-level and chronological matched children on a series of morphological tasks. The dyslexic group performed below the chronological age matched group for all tasks. However, comparisons with the reading-age matched group indicated that whilst dyslexic children were poorer in the morphemic segmentation tasks, they performed normally for their reading level in the sentence completion task, and even produced more words in the production task.

These findings may support the simple view of reading in two ways. Firstly, the decoding deficits shown by children are probably not just phonological. This study highlights that children with dyslexia struggle with segmentation at larger units (i.e., morphemes) and signals a broad decoding deficit. Secondly, the children with dyslexia who manage to read as well as typically developing children are clearly using other skills to compensate for poorer decoding ability. Evidence from this study would suggest that the linguistic comprehension aspect of morphology (tapped by the sentence completion task) is such a skill. However, this is speculative. One of the aims of this thesis was to elucidate the role of morphological awareness in decoding and reading comprehension.

1.4.2 Morphological Underpinnings

A key issue is that several of the models discussed above do not make explicit reference to the role of morphology in reading development. It is often referenced (for example as larger grain sizes in Grain-size theory; Grainger & Ziegler, 2011) but not specifically examined. Developmentally, children typically first acquire the alphabetic principle through formal instruction (Castles et al., 2018), particularly in the UK where systematic phonics instruction is mandated. However, in becoming skilled readers, children use their understanding of morphemic boundaries to more effectively read words.

Although it seems clear that there are different mechanisms for word recognition, the lexical and non-lexical routes of the dual-route model may not be entirely independent (Humphreys & Evett, 1985). For example, let us assume that a child is able to automatically encode each of the familiar single morpheme words *home* and *less* via the lexical route. It follows then that if the child accesses the less familiar multimorphemic word *homeless* via the non-lexical route, they should do so at a larger morphemic grain size (i.e., making use of their lexical representations of *home* and *less*).

Early studies investigating how morphologically complex forms might be processed lend credence to both lexical and non-lexical routes of processing. Stemberger and MacWhinney (1986), for example, found evidence to suggest that regular high-frequency inflected forms are stored lexically, as wholes, whilst lower-frequency forms are made through morphological rules. Speech errors were analysed from a corpus of 7,200 errors collected from adult native English speakers in natural speech situations. High-frequency words yielded significantly fewer errors than did their lower-frequency counterparts. However, the investigators concluded that further research was necessary to fine tune the mechanism by which individuals decide when and how to use each pathway.

The Morphological Pathways Framework has addressed the gap for a model to explain the multidimensional role of morphology in both word reading and reading comprehension (Levesque et al., 2020). Whilst there exists several guidelines for understanding phonology development and its role within literacy development (e.g., The Alphabetic Principle; Ehri, 2005), there is a lack of specific parameters for morphology.

1.5 Morphological Awareness

1.5.1 Morphological Awareness in Language to Later Literacy

Morphology is the linguistic study of morphemes; the smallest units of meaning in a word. For example, in the multimorphemic word *player', play*, *-er,* and *–s* are morphemes. Bound morphemes cannot stand alone (e.g., *-er*) and must be attached to a free morpheme to make a word. Affixes are bound morphemes that are used to alter the meaning of a word (Lehrer, 2000). There are two types of affixes in English: Prefixes precede the word (e.g., *un*) while suffixes follow the end of the word (e.g., *-y*) (Ramirez et al., 2014). Free morphemes, on the other hand, are also standalone words (e.g., *play*). The root of the word refers to the smallest unit of meaning within the word which carries the most significant semantic content and may or may not be a standalone word (Burani & Laudanna, 1992). For example, the root of the word *cats* is *cat*, and the root of the word *untied* is *tie*. The stem refers to a standalone word which may contain derivations but before any inflections are attached. Thus, using our earlier example, the stem of *cats* is still *cat*, but the stem of *untied* is *untie*. The base, more generally, refers to any standalone root or stem to which an affix is attached (Chialant & Caramazza, 1995). Therefore, *cat*, *tie* and *untie* may all be treated as bases to which affixes may be attached. For the purposes of this thesis, the term ‘base’ will be used to describe the lexeme form prior to the attachment of a suffix.

Defining a unified skill that may be attributed to morphological awareness has been challenging due to the variations across tasks and researchers. Examples of the factors that cause discrepancies are the modality of assessment (oral vs written), skill type (receptive vs productive), level of understanding (implicit vs explicit), morphemic structure (compounds vs suffix vs pre-fix), and affix type (inflections vs derivations) amongst others (Mann, 2000). Further compounding matters, many of these terms may be defined differently across studies (Apel, 2014).

As an example, some authors have proposed definitions and tasks which suggest that morphological awareness is an oral language skill (Carlisle, 1988; Deacon et al., 2013; Wolter et al., 2009), whilst others assert that any definition of morphological awareness must encompass the written expression of this skill (e.g., Apel & Thomas-Tate, 2009). This is an important distinction to consider for two reasons. If morphological awareness is necessarily a written skill, an assumption is made that younger pre-literate children do not possess it (Carlisle & Feldman, 1995). Further, if morphological awareness is deemed to be a written skill, validity issues may rise wherein orthographic effects in literate children are inadvertently taken as morphological effects (Deacon et al., 2009). Yet very few studies have sought to elucidate this matter empirically by examining morphological awareness in the oral language of beginner readers.

In an attempt to clarify this issue, Apel et al., (2013) administered four different types of morphological awareness tasks to kindergarten students (5-6-year-olds), first grade students (6-7-year-olds) and second grade students (7-8-year-olds). The tasks presented were a written production task, a written identification task, an oral production task and an oral production/judgement task. What became clear was that different types of tasks measured unique aspects of morphological awareness. What is more, these different tasks uniquely predicted different aspects of reading at different grade levels. Of note, the authors concluded that the production task may be most useful for discerning morphological awareness scores between all three grades (e.g., *Friend. The substitute teacher was very* _______). This is an important point to note as the other tasks suffered issues of unsuitability for the younger students, or an inability to find significant differences between the older students.

Despite the inconsistencies and perhaps due to its multifaceted nature, morphological awareness has been described as an index for several language and literacy skills including phonological awareness, semantics, and orthography (Carlisle & Stone, 2003). For example, in order to decode and understand the less frequent morphologically complex word *equivocal*, we need to phonologically segment, understand the significance of the affix, know the orthographic boundary of the morphemes, and define the root. Thus, morphological awareness contains overlaps in the same language skills that have been deemed to be separable in their contributions to later literacy.

A pertinent question then might be how morphological awareness in early oral language contributes to later literacy. Yet many researchers do not consider morphological awareness as a key skill in literacy development (Wolter et al., 2009). In those studies where the skill is considered it may, for example, be attributed a minor supporting role such as a component of structural language (e.g., Roth et al., 2002). Others argue that metalinguistic abilities such as morphological awareness are shaped by the writing system in older children and not vice versa (Nagy & Anderson, 1999). Yet although there remains a dearth of research that has investigated morphological awareness in the language of pre-readers, several longitudinal studies have found a clear predictive influence of morphological awareness on various literacy skills in primary school age children.

Deacon and Kirby (2004) examined the role of morphological awareness in the reading development of children across four years from the age of seven. The morphological awareness task employed was an analogy task using regular and irregular past tense verbs. For example, the experiment presented orally: Peter plays at school. Peter played at school. Peter works at home. Peter _______ at home. Morphological awareness tested at the initial time point contributed to variance in all measures of reading over time including single word reading, pseudo-word reading and reading comprehension. These contributions were comparable or greater in strength than those of phonological awareness and significant even after controlling for phonological awareness and intelligence. Another important finding was that morphological awareness skill at the first testing time point contributed significantly to literacy skills four years later. Finally, morphological awareness contributed similar levels of variance to reading comprehension and pseudo-word reading but less to single word reading. This indicates that not only is morphological awareness useful for reading comprehension as has been often shown, but it is also a useful skill in word reading. Moreover, this is better highlighted in pseudo-word reading where children might analyse pseudo words in their constituent morphemes.

Similarly underlining a relationship between morphological awareness and word reading, (Deacon et al., 2014) found that there was a direct language structure-based effect between morphological awareness and reading comprehension in upper primary school years and an indirect effect via word reading in middle primary school years. Indeed, this finding partially supports the notion that although morphological awareness is an important skill, it does not directly contribute to literacy skills until late primary (Berninger et al., 2010) or even secondary school years (Nagy et al., 2006). However, the issue is unclear as a vast and varied number of different types of morphological awareness tasks have been used in studies (Apel, 2014). For example, Carlisle & Feldman (1995) tested children longitudinally in Kindergarten (5-6-years old), Grade 1 (6-7-years old) and Grade 2 (7-8 years old) to investigate the relationship between early morphological awareness and later reading achievement. Significantly-as most other findings indicate that children do not benefit from Morphological Awareness until later- they found that the skill contributed to reading achievement from 6 to 7-years-old. Analysis at the age of five years was unviable due to a large number of missing data. The task used was receptive and examined morphological knowledge (e.g., *Do you think the word fabulous comes from the word fable? Have you ever thought about this before?*). It is impossible to ascertain whether 5-year-old children had high error rates on this task due to a lack of morphological knowledge or whether it was due to immature cognitive development and an inability to understand the instructions.

Therefore, although the evidence suggests that morphological awareness in children as young as six contributes to later literacy development, further research is needed with a task suited to younger learners to gauge how morphological awareness in pre-school oral language contributes to literacy development. One study that has investigated this relationship, Wolter et al., (2009) examined morphological awareness in the oral language of 6-year-olds and its predictive influence on literacy. The oral morphological production task used demonstrated morphological awareness in young children, as Berko (1958) also found in a similar non-word variation of the task. Further, performance on the morphological awareness task accounted for 9.6% and 7.4% of unique and significant variance on reading and spelling tasks respectively, above and beyond the contributions of phonological awareness. Taken together, the results provide convincing evidence for the importance of morphological awareness skills in early years education. However, as a cross-sectional study, it lacks the scope to provide information about the developmental trajectory of morphological awareness and its relationship with literacy development. The relationship between morphological awareness and literacy is further discussed in 3.2.2 Morphological Awareness and Literacy Development.

1.5.2 Oral morphological learning

Importantly, we need to understand the mechanisms by which pre-school children's morphological knowledge might inform their subsequent literacy development. The development of written morphology follows much the same pattern of oral morphology (Green et al., 2003). It is known that children first develop productive use of inflectional morphology in speech at an early age- from 3 or 4 years old- signalling an oral language basis for this skill (Berko, 1958; see Chapter 2 for a review). Further, exposure to morphological complexity and richness in child-directed speech is linked to the speed of development of noun and verb paradigms in child speech (Xanthos et al., 2011). Unsurprisingly, being presented with the various combinations of verb and noun forms involved in multimorphemic words aid in children's conceptualization of verb and noun paradigms.

Unlike literacy skills such as letter knowledge, morphological awareness does not require explicit instruction in order to be acquired. Morphological structure is inherent in everyday language and is naturally acquired in children's speech. However, the metalinguistic aspect of morphological awareness- that is the ability to reflect on the role of morphemes- may require further maturation and/or explicit instruction (Nagy & Anderson, 1999). Indeed, this may be the reason that several researchers argue that morphological awareness only becomes useful in later primary years. However, it is important to note that morphological awareness is a skill which develops over a long time span: as discussed earlier, morphological knowledge acquisition begins before school and continues into adulthood (Dawson et al., 2018; Guo et al., 2011; Kuo & Anderson, 2006). Thus, although certain aspects of morphological learning (e.g., derivational morphology) may only be accessed in late primary years and beyond, others are developed and even mastered very early on (Apel et al., 2013a; Tong et al., 2011).

In the early years, several factors affect children's morphological learning. Firstly, phonological analysis is necessary for children to access the phonological representation of morphemes (Carlisle, 2003), and as expected, transparent phonological shifts (e.g., *allow-allowable*) are more readily used and understood than opaque ones (e.g., *acid-acidic*) (Windsor, 2000). In these early years, morphological processing is dependent upon access to representations of full forms, base forms and affixes (Colé et al., 1997).

Secondly, children use both rule and analogy-based principles in morphological learning (Clark, 2017), depending on language maturity and domain. Children may first attempt morphological composition via analogy followed by a rule-based route with further language exposure. It follows then that morpheme frequency and productivity are important indicators for morphological processing. Productivity refers to the number of base words to which an affix (or suffixes) may be attached within the constraints of morphological rules. More frequent encounters with a specific class of morphemes, will lead to increased access to the governing morphological rule, and more productive affixes will be encountered more frequently.

1.5.3 Learning inflectional and derivational rules

One aspect of morphological learning which contributes to its long timespan from prereaders to adulthood is the distinction between inflections and derivations. Inflections refer to different forms of the same lexeme, which have the same meaning and lexical category (Booij, 1996). Inflections serve a primarily grammatical function. For example, *singing*, *sings*, and *sing* are all different forms of the same lexeme. Similarly, the plural form of a lexeme is an inflection of the singular form (e.g., *bird* and *birds*). Derivations, conversely, involve a process by which an affix is attached to a lexeme to create a lexeme of different meaning and lexical category. For example, the derivation *cloud* to *cloudy* results in a shift from noun to adjective.

By the age of seven or eight, most children can consistently and appropriately apply the morpho-phonological rules (i.e., specificities in the sounding out of complex words) for the formations of inflections in oral language (Berko, 1958) . Further, children as young as five demonstrate an understanding for the role of inflections, but not derivations in spellings (Deacon & Bryant, 2006). Similarly, Wolter et al., (2009) found that 6-year-olds were able to use morphological information in a spelling task although this contained a combination of both inflections and derivations.

Derivational learning, on the other hand, is a more gradual process which starts later. For example, children appear to develop sensitivity to derivations in spellings by approximately 9 years of age (Sangster & Deacon, 2011). This may be due to increased complexity, with the assumption that grammatical devices with relatively more complex rules are acquired later (Hyams, 2008). Derivational suffixes have a more complex relationship with their base form than do inflectional suffixes. Whereas inflectional affixes maintain the lexical category of a word, derivational affixes change them.

Another factor may be frequency; inflectional transformations are encountered more frequently than derivational ones (Tong et al., 2011). Green et al., (2003) found that the majority of 8-10-year-olds consistently and accurately used inflectional forms in their writing. In contrast, fewer children used derivational forms accurately and as expected, this skill improved from the younger to older children. Word-specific learning may form the basis for the acquisition of morphological rules (Chliounaki & Bryant, 2007), therefore the rules for the more frequent inflections may be learned more readily than those for derivations because they are encountered more frequently.

1.6 Phonological Awareness

Yet another question which has divided researchers is the extent to which the development of morphological awareness is borne out of phonological awareness skills. Although morphological learning is broadly dependent upon several underpinning skills, some argue that early morphological awareness is driven by the same mechanisms that underpin phonological awareness (Embick, 2010). At the very least, morphological awareness and phonological awareness are strongly interrelated (Carlisle & Nomanbhoy, 1993).

Phonological awareness refers to the extent to which an individual is sensitive to the sound structure of oral language (Anthony & Francis, 2005). It involves phoneme awareness- the ability to manipulate individual sounds (phonemes) and the ability to make judgements about basic phonological patterns such as whether two words rhyme.

Interestingly, some of the same issues that have affected the study of morphological awareness have also affected the study of phonological awareness. Firstly, several different tasks have been employed to assess phonological awareness. Some of the more widely used tasks include segmenting (separating words into their constituent phonemes), blending (adding phonemes together to make a word), deletion (saying a word without one of its phonemes) and various phonological judgement tasks (e.g., analysing words which rhyme). The most significant issue here is that although the different tasks may be tapping phonological awareness skill pre-dominantly, they all require differing levels of cognitive ability (Stanovich et al., 1984). For example, if a child is at floor/ceiling on a given phonological awareness task, the predictive ability of this task may be limited. Conversely, a task which allows for a range of scores may better predict reading and other literacy skills.

Nevertheless, phonological awareness tasks tend to be equally or more highly predictive of literacy skills than global cognitive abilities (Stanovich et al., 1984). Due to the variety in tasks which may be used to assess phonological awareness, it is not surprising then that various researchers have ascribed different meanings to phonological awareness. As just one example, Burt et al., (1999) describes phonological awareness as a non-unitary construct Anthony & Francis, (2005) contends that it is unitary. Burt et al., (1999) argued that phonological awareness is not unitary due to the potential for words to be broken down into at least three different phonological units (syllabic, intrasyllabic and phonemic).

On the other hand, Anthony and Francis (2005) acknowledges the various phonological units involved in phonological awareness but argues that the construct is unitary, and that phonological awareness may be manifested by different tasks throughout development. Evidence for this has come from large-scale longitudinal studies which show that several different phonological awareness skills are highly inter-related (e.g., Schatschneider et al., 1999) and moreover that individual differences in phonological awareness are stable across time and different phonological awareness tasks (Anthony & Lonigan, 2004).

1.6.1 Phonological Awareness Development

The development of phonological awareness has been well studied across differing ages, abilities and tasks, especially relative to the number of studies on morphological awareness development (Wang et al., 2006). Children must first gain alphabetic knowledge – the ability read and/write the alphabet, and articulatory skills, followed by awareness of onsets and rimes in order to read words and perform complex phonemic analysis (Carroll et al., 2003; Johnston et al., 1996; Stahl & Murray, 1994). The process of acquisition of phonological awareness in oral language seems to contrast with that of written language. During the pre-school years in oral language, children recognise larger phonological units like syllables followed by onsets and rimes followed by individual phonemes (Goswami & Bryant, 1990).

This pattern is reversed in written language. For example, Hulme et al., (2002) found that for beginning readers (5-6 years old), phoneme awareness was a better concurrent and longitudinal predictor of reading skills than onset-rime skills. On the other hand, Haskell et al., (1992) found that intermediate readers (6-7 years old) performed better at reading accuracy after onset-rime level instruction than other phonological unit levels, particularly for exception words. Taken together, these studies highlight the pattern of phonological unit detection from larger to smaller in pre-literate oral language and smaller to larger in reading for older children.

An important point to note regarding the development of phonological awareness is that children must first be explicitly taught individual sounds using alphabetic knowledge before then developing the ability to recognise larger units. Arguably, children may not simply glean this awareness independently from their environment. Mann (1986) found that whilst 6-7-year-old American English-speaking children are aware of both phonemes and syllables, Japanese-speaking children are only aware of syllabic units. This is probably due to the language instruction practice in Japan where syllables but not phonemes are explicitly taught. This finding provides evidence for the notion that alphabetic knowledge, the foundation for phonological awareness, must be taught and may not simply be acquired naturally in language.

One important question then is whether young children possess any skills which contribute to the development of phonological awareness. There is evidence that pre-literate children can attend to global similarities in the phonological structure of language, and that this skill is predictive of phoneme awareness (awareness of individual phonemes) (Byrne & Fielding-Barnsley, 1993; Cardoso-Martins, 1994; Carroll & Snowling, 2001). For example, Carroll et al., (2003) carried out a longitudinal study investigating the development of phonological awareness in 3- and 4-year-old pre-literate children. Results showed clearly that both syllable and rime awareness develop before phoneme awareness. However, there was little difference between the syllable and rime awareness tasks. Notably, both of these skills did load highly on a single latent variable, large segment awareness, supporting evidence for progression from awareness of large units (e.g., syllables and rimes) to awareness of small units (e.g., phonemes). This progression was further categorized as a development from implicit skills in global sound similarities to explicit skills in phoneme awareness.

Finally, an important factor in this process of acquisition is the phonological structure of language. Varying preponderance of different phonological units in languages results in differences in sensitivity to these units. For example, Caravolas and Bruck, (1993) found that the phonological input characteristics of English and Czech differentially shaped the patterns of phonological awareness in English-speaking and Czech-speaking children. Czech-speaking children possess higher levels of awareness of complex onsets and consistently, Czech has 258 different cluster onsets. Conversely, English-speaking children were better at isolating onsets with one consonant and consistently, English has just 31 cluster onsets. It is argued that phonological awareness is more closely linked to deciphering novel words than recognizing familiar ones (Baron & Treiman, 1980). Siok and Fletcher (2001) similarly argue that the relationship between morphological awareness and reading is dependent upon the characteristics of the writing system. In their study examining the predictive ability of phonological awareness for reading success, it was found that visual skills, character discrimination and onset-rime awareness, but not phonemic awareness predicted Chinese reading.

1.6.2 Comparisons Between Morphological Awareness and Phonological Awareness

Just as more research has been carried out into phonological awareness than morphological awareness, early years literacy instruction too has focused more on phonological awareness (Cunningham & Carroll, 2011). This could be due to several reasons. One reason may be that in learning to read, the smaller units involved in phonological awareness may be more accessible to young children. Another reason could be the strong relationship between phonics instruction and reading development which has been consistently and widely found in the literature (Goswami & Bryant, 2016; Rack et al., 1994).

Yet phonological awareness has to be explicitly taught whilst morphological awareness does not. Everyday speech does not highlight individual phonemes in words nor can alphabetic knowledge be gleaned through conversation. Children may, on the other hand, become sensitive to the way in which different morphemes, particularly inflectional suffixes are combined in speech. Counteracting this, however, is the developmental trajectory of each skill. As highlighted, inflections are mastered by the age of five or six (Berko, 1958; Carlisle & Feldman, 1995) and derivations continue to develop into secondary school (Nagy et al., 2006). Yet whilst phonological awareness is a strong predictor for literacy success in early primary years, it does not contribute as strongly to literacy outcomes later on (Carroll et al., 2003; Cunningham & Carroll, 2011). Berninger et al., (2010) assessed the growth in phonological, orthographic and morphological awareness in children from age 6 to 11. Phonological awareness, orthographic awareness and three kinds of morphological awareness showed the greatest growth in the primary years. However, derivational morphological awareness continued to show substantial growth after age 9. This study highlights the differences in the developmental trajectories of morphological and phonological awareness. While both skills are effective in the early primary years, morphological awareness appears to develop over a longer period.

Nevertheless, the precursors of both morphological awareness and phonological awareness lie in oral language. An important way in which the development of phonological awareness and morphological awareness differ is in their types of pre-cursor skills in oral language. For phonological awareness, this seems to manifest in a child's ability to attend to global similarities in words such as rhyming as well as articulation ability (Carroll et al., 2003). In contrast, for morphological awareness, this appears to be related to vocabulary (Ramirez et al., 2014), although there has been a much greater focus on the contributions of morphological awareness than on its foundations.

Turning to their differential contributions to literacy, generally, phonological awareness has been shown to contribute to word reading whilst morphological awareness has been shown to support reading comprehension (Cunningham & Carroll, 2011; Deacon & Kirby, 2004; Gray & McCutchen, 2006). Phonological awareness taps decoding skills necessary for reading (Swank & Catts, 1994). Conversely, morphological awareness taps semantic knowledge and morphological analysis necessary for comprehension (James et al., 2021; Levesque et al., 2017). Yet, the picture is unclear. Confusingly, some studies have found that morphological awareness does in fact contribute to word reading (Apel & Lawrence, 2011) and that phonological awareness contributes to reading comprehension (Catts et al., 2002). Several factors cloud the issue. Studies have tested morphological awareness and phonological awareness at different ages, and they may affect literacy measures differently as children develop. Other issues include tasks which tap extraneous variables (e.g., working memory) and the lack of longitudinal studies which can disentangle the variables.

1.7 Measuring Morphological Awareness and Morphological Processing

Importantly though, much remains underspecified in morphological research relating to early morphological development in both the linguistic and orthographic domains. This may be due to general assumptions about the timeline of morphological development; it has been contended that children under the age of seven are unable to use and make use of morphology consciously in their language and writing (Nagy et al., 2003, 2006). Further, younger children (from age 5), are exposed to systematic phonics instruction alongside morphology instruction in the form of limited simple suffixes which may strengthen the former (Rastle, 2018). Thus, the question should not be whether children use morphology consciously, because due to its lack of formal instruction, it would be unsurprising that they do not. The question instead should be whether very young children (e.g., from 5-years old) are able to use morphology explicitly. In order to examine this issue, several different types of tasks have been used. In the sections below, I discuss some of the methods used to assess firstly morphological awareness, and secondly morphological processing in young children.

1.7.1 Morphological Awareness

One way to measure the timeline for the impact of each skill might be to examine intervention studies. Nunes, Bryant and Olsson (2003) found that both morphological training and phonological training led to improvements in word identification for 7-8-year-olds. However, whilst morphological training led to improvements in the use of morphological spelling, phonological training did not lead to improvements in phonologically based spelling rules. One hypothesis for this puzzling finding was that the children may already be saturated with phonological awareness intensive lessons. This specifically highlights the potential impact of morphological awareness training alongside phonological awareness in classrooms. Since phonology-based interventions are already so widely used in classrooms, further phonological training might not be as effective as morphological training. In their review on morphological awareness intervention studies, Carlisle (2011) determined that instruction in morphological awareness has the potential to contribute to phonology, orthography and word meaning. However, the design and quality of research was called into question. Two systematic review papers of morphological instruction studies, Bowers, Kirby and Deacon (2010) and Goodwin and Ahn (2010) have reported largely similar findings: Morphological awareness contributes significantly to literacy improvement and this instruction is particularly useful for children with literacy difficulties. Of course, this finding of stronger effects may be due to children with literacy difficulties having lower baseline measures to begin with. However, the findings are still valuable in highlighting the potential positives for increased morphological awareness training for children.

Taken together, these studies suggest that young children are able to use morphological awareness in strengthening their literacy skills, particularly when its training is afforded to them. Therefore, arguably, a lack of finding of morphological awareness in traditional assessments might not be due to children's inability to understand morphological structure, but to research task demands and minimal morphological instruction in early school years. Yet, intervention studies, which address these issues, are not always feasible due to time constraints and fidelity issues (implementation as intended by the researchers) when delivered by teachers (Gersten et al., 2000). This may be the reason why intervention studies, often touted as the gold-standard for education research, are on decline (Hsieh et al., 2005). Intervention studies are often lengthy, requiring pre-test, several months of instruction, and a post-test. Thus, the interventions are usually implemented by teachers which raises issues of inconsistencies in scaffolding, dedicated time and effort. Moreover, allocating specific sessions for intervention training may interfere with the school's usual timetable for learning.

Addressing all of these concerns about intervention studies, dynamic assessment is a method to measure morphological awareness in very young children (Larsen & Nippold, 2007). Static assessment attempts to measure a particular skill without intervening or changing the outcome in any way. Dynamic assessment, on the other hand, provides continuous support during assessment in order to both change a child's performance, and assess the extent to which the child's performance is able to change with guidance. Importantly, it does not simply record the child's actual level of skill, as do static tasks, but evaluates their ability to learn the skill (Tzuriel, 2000). Thus, it is particularly suited to assessing seemingly higher-level, metalinguistic skills such as morphological awareness in younger learners.

Yet very few studies have used dynamic assessment in this manner. The few studies that have examined morphological awareness using dynamic assessment have been cross-sectional and/or assessed older children with substantial literacy instruction (Larsen & Nippold, 2007; Ram et al., 2013; Wolter et al., 2020; Wolter & Pike, 2015). Therefore, a primary aim of this thesis was to develop and evaluate a dynamic assessment of morphology in beginner readers (5-6-years old). Moreover, this assessment was used to investigate how morphological awareness in oral language of beginner readers contributes to literacy skills after a year of formal education.

1.7.1.1 Morphological Awareness in Beginner Readers

It is clear that traditional tasks may be ill-suited for testing morphological awareness in younger children (i.e., below 7 years-old). Yet, it is important to also consider whether there is any merit in studying morphological awareness in younger children at all. Examining morphological awareness in beginner readers is important for several reasons. One evident reason is that there is a lack of knowledge and consensus as to whether children possess morphological awareness, and whether morphological awareness contributes to early literacy development. Children as young as 6 have been found to apply a morphological strategy without explicit instruction (Wolter et al., 2009). Yet, most research has focussed on morphological awareness in children aged 8 and above, perhaps highlighting Erhi's consolidated phase (Levesque et al., 2020). Hence it is difficult to determine the answer to these questions with any certainty. Moreover, it may be argued that in order to truly elucidate the role of morphological awareness in literacy development, its early role must be better understood.

Another compelling reason to examine morphological awareness in beginner readers is the nature of morphology itself. As mentioned previously, morphemes are multidimensional linguistic codes which carry information about semantics, orthography, grammar and syntax. High quality lexical representation involves overlapping of several sources of lexical information (Perfetti & Hart, 2002). Morphological awareness enhances the quality of lexical information available to the reader, providing further cues to support decoding and comprehension (Levesque et al., 2020). Children may implicitly take advantage of this by using morphological strategies, bootstrapped by early morphological awareness in language. If this is the case, further investigation may encourage morphological instruction in younger children to support reading. Indeed, as highlighted in the section above, morphological intervention contributes to literacy development in children as young as 7 years-old (Nunes et al., 2003).

Finally, assessing morphological awareness in the language of beginner readers may yield a 'purer' measure of the skill. Several researchers have argued that morphological awareness supports reading by increasing sensitivity to morphological structure (Carlisle & Nomanbhoy, 1993; Wolter et al., 2009). One suggestion is that morphological awareness may support this process by mapping morphemic units from speech to print. According to The Morphological Pathways Framework, the path between morphological awareness in the Linguistic System and morpheme units in the Orthographic System is underspecified. In order to clearly investigate this path from morphological awareness in language to morpheme units in the Orthographic System, the effects of orthographic knowledge should be minimised. Most studies test morphological awareness at a stage when the effects of literacy instruction cannot be separated from morphological awareness itself. Often, morphological awareness is measured orally in order to decrease the likelihood of inadvertent orthographic effects (e.g., Deacon et al., 2009). Yet in more skilled readers, these orthographic effects may still contribute when testing MA concurrently. By examining morphological awareness in novice readers, reading skill is largely bypassed, allowing for an assessment of metalinguistic knowledge grounded in language skills (Diamanti et al., 2018). Thus, we are able to assess, to a greater extent, whether it is morphological awareness in language that has contributed to literacy development and not some consequence of reading skill.

1.7.2 Morphological Processing

Morphological awareness from oral language supports understanding of morphological structure, which in turn leads to enhanced morpheme decoding strategies during morphological processing. Whilst morphological awareness refers to the metalinguistic skill involving morphemes, morphological processing refers to the actual recognition of morphologically complex words (Beyersmann et al., 2020). Morphological awareness in oral language may be viewed as the foundation for later morphological processing through increased sensitivity to morphological structure. For example, Arnbak and Elbro (2000) investigated the effects of an oral morphological awareness training intervention on children with severe reading and writing problems (mean age = 11 years). They found that oral morphological awareness training led to significant improvements in reading comprehension and spelling of morphologically complex words compared to controls. However, there were no appreciable gains in phonological awareness. From these results, two interesting arguments can be made. Firstly, although the training was only carried out orally, it still had a positive impact on literacy-based written skills. The authors suggested that this was due to a strengthened awareness of morphological structure. Secondly, the absence of improvements for phonological awareness suggests that morphological awareness is a separable skill that can independently impact literacy attainment.

Crucially, researchers have sought to understand more about the mechanisms which underlie morphological processing during reading. During morphological processing, readers access knowledge about morphological structure to read morphologically complex words (Beyersmann et al., 2012). This is particularly relevant for children as they increasingly encounter longer, morphologically complex words (Green et al., 2003). Yet, it can be difficult to distinguish between reading based upon grapheme to phoneme correspondences and reading based upon morphological processing (Verhoeven & Perfetti, 2011). Moreover, a key question which is still debated, is whether morphological processing occurs independently during reading, or whether it emerges at the intersection of orthographic and semantic activations (Frost et al., 2005). In order to answer these questions, research has taken two main routes, morpheme frequency and morphological priming, which show morphological effects in word identification (Amenta & Crepaldi, 2012). The idea is that effects found on the basis of manipulating morphologically complex words suggest sensitivity to morphological structure during reading.

Morpheme frequency effects are shown when the frequency of the individual morphemes within words are manipulated. Specifically, base frequency effects may be evidenced by decreased processing time for familiar base forms compared to unfamiliar base forms, particularly when the surface frequency is controlled (Deacon & Francis, 2017). These effects have been widely found and highlight that readers access morphemic units within words (Amenta & Crepaldi, 2012).

Morphological priming involves presenting a target word after exposure to its morphological relative (prime). Studies examining morphological priming have found overwhelming evidence for the importance of morphological form (Rastle et al., 2004), morphological semantics (Feldman & Soltano, 1999), or both on target word priming.

These studies have provided a wealth of knowledge about morphological processing during reading. Yet there are two key gaps which the current thesis addressed. Firstly, due to the nature of the tasks involved, naturalistic reading is not necessarily tapped because participants have focussed on single word reading and not sentence reading. Thus, in the current study, morphological processing was assessed using the eye-tracker in order to examine effects during normal reading and the time course of morphological processing. Secondly, and importantly, there remains a dearth of studies investigating morphological processing in children. Comparing morphological processing in both adults and children might provide insight into the differences between the skilled and novice readers' processing of morphological structure and give insight into the developmental changes of morphological processing.

1.8 Thesis Aims

In this section, the aims of the current thesis will be outlined. For each thesis study, hypotheses will be discussed within the context of the Morphological Pathways Framework.

Several studies have found that primary school age children have some degree of morphological awareness (Carlisle & Nomanbhoy, 1993; Cunningham & Carroll, 2015; Deacon & Kirby, 2004). Yet very few studies have examined this skill in children's language during their first year of formal schooling (i.e., 4-5 years old) when children are beginning readers. Moreover, a failure to find this skill in very young children may not be due to its absence but due to the excessive complexity of the tasks used in assessing cognitively immature learners. Thus, in chapter two, a dynamic assessment task of morphological awareness for young children was developed and then used to assess children of ages 3 to 10.

Experiment 1 involved the development of the task. The task was continuously updated whilst also being simultaneously administered to the children in a feedback loop. In this way, there was certainty regarding its suitability. Experiment 2 involved piloting the finalized task on a different set of children. This was done to ascertain the validity and reliability of the task.

In order to examine the contribution of morphological awareness in language to literacy development, it is essential to investigate this issue longitudinally. Accordingly, it is then possible to investigate how oral morphological awareness supports the child as they become exposed to their first year of formal education.

In chapter 3, the dynamic morphological awareness task developed in chapter 2 was used to assess 5-6 year-old children's morphological awareness in language. Literacy skills were assessed a year later. Phonological awareness has been viewed, arguably, as the most important skill for early literacy development (Castles et al., 2018). Therefore, it may be argued, understandably, that the role of morphological awareness in literacy is underpinned by mechanisms of phonological awareness due to an overlap in the skills required to succeed in tasks of each. Thus, many of the studies which investigate the relationship between literacy and morphological awareness have also assessed and controlled for the contribution of phonological awareness (e.g., Deacon & Kirby, 2004). In the current thesis, this was taken to a greater level of specificity by creating an analogous phonological awareness task, using similar-sounding phonemes to those in the dynamic morphological awareness task.

Most of the studies that have examined the role of morphology in literacy development have assessed children aged 8 and older (Beyersmann et al., 2012; Carlisle, 2000; Dawson et al., 2018). Yet, according to the Morphological Pathways Framework, children may access morphological structures and regularities at an earlier age (Levesque et al., 2020). This is due to the multidimensionality of morphology in providing young children with semantic, orthographic and grammatical cues for reading. Morphological awareness in early language may help children to learn to read in two ways. First, Morphological awareness supports morphological analysis, helping children to read by engaging semantics

(Deacon et al., 2010). Second, children may map morphemes from spoken language to written language during morphological decoding. Thus, in line with MPF, it was hypothesised that morphological awareness in developing readers would contribute to literacy skills a year later.

Finally, of interest was the development from morphological awareness in language to morphological processing in reading. If morphological awareness in language does support children's literacy skills, then it seems likely that older children would use that morphological knowledge to support their reading processes. Yet very few studies have explored this issue in children. Even among adults, studies which examine morphological processing have traditionally used tasks which are restricted to single word identification. Indeed, word reading typically occurs within the context of a sentence. This caveat is especially important when considering the argument that linguistic comprehension is a central part of reading. It is difficult to incorporate this factor when assessing single word reading.

Thus, in chapters 4 and 5, the eye-tracker was used to investigate children and adult's reading of morphologically complex words within sentences. In chapter 4, base and surface frequencies were manipulated in order to assess differential word decomposition processes in children and adults. In the MPF, children use their knowledge about morphemes to morphologically decode morphemic units from the Orthographic System to generate Lexical Representations. As expressed earlier, it is contended that this process of morphological decoding may occur earlier than is often predicted (for example in Ehri, 2005). Thus, it was expected that intermediate readers would use morphological decoding in order to read words. This would yield base frequency effects whereby words with low surface frequency, but high base frequency would be accessed by their more familiar base, thus reflecting morphological decoding. Adults, on the other hand, may be able to access whole words directly from the Orthographic System, bypassing the need for morphological decoding.

In chapter 5, morphologically complex words were primed by orthographically and morphologically related words in order to assess their relevance in the word processing of children and adults. Due to the multidimensionality of morphemes, it was predicted that morphologically related words would have a more facilitatory effect on target word processing than orthographically related primes. Indeed, the MPF suggests that word reading incorporates both morpho-semantic and morpho-orthographic as separable processes which both contribute to lexical access.

2 Development of the Dynamic Assessment of Morphological Awareness

2.1 Abstract

In this chapter, the assessment and learning components of dynamic assessment were combined in a sentence completion task of morphological awareness which closely mimics children's real-life use of morphology in speech production (see 1.1 Introduction for a working definition of morphological awareness). The aim was to create a dynamic assessment of explicit morphological awareness suitable for young children during the earliest stage of literacy acquisition. In experiment 1, the dynamic assessment of morphological awareness was piloted with 3- to 10-year-old children alongside its development allowing for ongoing amendments. In experiment 2, the final task was piloted with two age groups: The target age group (4-5 years old) and an older age group (6-8 years old). Results showed that the final task is a valid and reliable tool for assessing morphological awareness in beginner readers.

2.2 Introduction

Morphological awareness has been shown to contribute to a wide range of literacy skills in the primary years (Apel et al., 2013; Kirby et al., 2008; Singson et al., 2000; Wolter et al., 2020). Yet there remains a lack of knowledge regarding morphological awareness at the earliest stage of education, specifically in the first year (i.e., 4-5 years old). Examining morphological awareness in the oral language of such young children may provide important insights whilst avoiding orthographic effects. This is achieved in two ways. Firstly, due to the limited literacy exposure children have had in their first year of education, the influence of orthographic knowledge in solving morphological awareness tasks is minimised. This may result in a purer assessment of morphological awareness with less orthographic contribution. Secondly, assessing morphological awareness in children's oral language avoids the inadvertent tapping of orthographic skills that may occur in written language (Deacon et al., 2014).

Traditional static measures of morphological awareness for this young age group may be subject to floor effects due to cognitive immaturity, and not necessarily a lack of morphological awareness. Thus, in chapter 2 a dynamic assessment of morphological awareness was developed and piloted. Dynamic assessment is ideal for young learners as it provides scaffolding in the form of increasingly helpful prompts, thereby measuring the potential for learning (Tzuriel, 2001).

2.2.1 Implicit and Explicit Morphological Awareness

Measures of morphological awareness necessarily draw on both explicit morphological awareness and more implicit morphological processing (Nagy et al., 2014). Implicit awareness refers to the tacit more intuitive awareness of the morphemic structure of words (Carlisle & Feldman, 1995). Generally, identification and judgement tasks may be deemed as measuring implicit awareness of morphology (Apel et al., 2013). In typical developmental progression, implicit morphological awareness has been shown to precede explicit knowledge (Apel, 2017).

Explicit morphological awareness, on the other hand, generally requires more than just the recognition of morphological structure and necessitates some sort of metalinguistic manipulation of the morphological structure of words to produce a tangible response. Specifically, explicit morphological awareness may be tapped by productive tasks such as completion (Berko, 1958), definition (Carlisle, 2000), and blending/segmenting (Casalis et al., 2004).

Of note, young children begin to display this explicit morphological awareness in their language even before literacy acquisition. This can be observed, for example, from overregularisations in children from age 2 into school-age years (Marcus et al., 1992). In this example, children mark verbs for tense reliably but erroneously extend this morphological rule to irregular forms (e.g., my teacher *teach-ed* me that). Indeed, this is a general phenomenon with children extending much of their reading vocabulary from language (Phythian-Sence & Wagner, 2007). Therefore, it would be beneficial for tasks which measure explicit morphological awareness of younger children to tap this knowledge in spoken rather than written language. By doing this, researchers are able to highlight explicit morphological knowledge which would otherwise be inaccessible in young pre-literate children.

Furthermore, testing morphological awareness in young children with less developed literacy, allows for a purer measure without orthographic support. In older children and adults with mature literacy skills, knowledge of the way a word is written may lead to visual representation of the written word. However, there is a dearth of tools for assessing morphological awareness in pre-literate children.

2.2.2 Sentence Completion Tasks

Sentence completion tasks have been widely found to be useful in measuring morphological awareness in children, tapping explicit and not implicit knowledge (Carlisle & Nomanbhoy, 1993. In order to gain a better understanding of the progress of the use of this task to investigate morphological awareness, it might be useful to consider its origins.

The original sentence completion task was developed by Berko (1958) using nonsense words. The aim was to assess whether young children (4-7 years old) had awareness about the rules that govern the usage of morphologically complex words. For example: *'This is a wug /wAg/. Now there is another one. There are two of them. There are two -'.* Berko argued that if children are able to complete the sentence using the appropriate multimorphemic non-word, this would infer that the child has necessarily performed some sort of morphological generalisation on the basis of knowledge of morphological rules. By contrast, real words might allow the child to generate the correct word on the basis of a stored lexical representation in memory using the sentence as context.

Findings were mixed with children able to extend some inflections to non-words (e.g. -*z* to the plural of the non-word *wug*) but not others (e.g. *ez* to the plural of the non-word *tass*). It was concluded that children model the application of morphological rules on forms that appeared frequently and consistently in their everyday oral language.

2.2.3 Real words or Non-words in the Assessment of Morphological Awareness?

Using non-words to assess morphological awareness does have merit but is restricted in its scope to comprehensively assess a child's morphological knowledge in several ways. Firstly, the use of nonsense words excludes the contributions of context (e.g., comprehension), semantics and vocabulary whilst over relying on phonology. This is perhaps due to the absence of a whole word lexical representation. For instance, consider that a child might use their morphological awareness to decompose an unfamiliar morphologically complex word into its constituent morphemes to derive meaning (Apel, 2017). This emphasizes the importance of semantics in morphological awareness; that which might be lost in the use of non-words. And further, while some researchers contend that morphological awareness may merely be considered in terms of larger-scale phonetic segmentation (e.g., Carlisle & Nomanbhoy, 1993; Shankweiler et al., 1995), several studies have shown that morphological awareness is very closely linked to both vocabulary and comprehension, beyond any contributions of phonological awareness (Deacon & Kirby, 2004; Guo et al., 2011; Kieffer & Lesaux, 2012).

Secondly, tasks using nonsense words might lack ecological validity, leading to potentially spurious findings. For example, Singson et al. (2000) administered a morphological awareness sentence completion task with both real words and nonsense words to 9, 10, 11 and 12-year-olds. Interestingly, children found the adjectival suffixes significantly easier than noun or verb suffixes for real words, with the reverse significant pattern found for nonsense words. This suggests that children use a different process to compute the non-word, due perhaps to the lack of additional cues that would be provided by real words (e.g. vocabulary and context). If this is the case, there should be question as to whether tasks using non-words can adequately reflect children's real-world morphological awareness and their use of morphemes.

Finally, although a picture and sentence are often provided (e.g., in Berko, 1958) to put the non-word into context and ascribe a meaning for it, this meaning is perhaps not as rich or deep as the meaning that already exists for the real word. Therefore, the role of semantics in this derivation task is underestimated. Non-words may be inaccessible to young children because they find it harder than older children to understand their meanings within the context of the task. Due to the arguments outlined above, real words were used in the current study.

2.2.4 Production or Decomposition Sentence Completion?

Another consideration to take into account is the type of sentence completion. Carlisle (2000) teased apart the differences between skills tapped in production and decomposition sentence completion. In decomposition sentence completion tasks, the participant must complete a sentence with a base word, given the morphologically complex variant (e.g., *'Growth. She wanted her plant to____. [grow]'*). In production sentence completion tasks, the participant must complete a sentence with the appropriate morphologically complex word, given the relevant base form. (e.g., *'Farm. My uncle is a____. [farmer]'*).

One might argue that production completion tasks are particularly useful for tapping metalinguistic understanding because they require the participant to consider the semantic and grammatical relationships between the word and the base. Further, this involves recall and analysis of the suffix and understanding of how the integration of morphemes affect the grammatical role of the morphologically complex word within the sentence (Snow, 1991).

Whereas in the decomposition task, the answer is provided within the given word (e.g., *grow* from *growth*), in production tasks, the participant must derive the correct answer on the basis of their knowledge of morphological rules (e.g. *farmer* from *farm*). Indeed, Carlisle (2000) found that the 8-9-year-olds in their study performed better on the decomposition than the production sentence completion, perhaps due to the greater metalinguistic load of the latter. Therefore, in the current chapter, a production sentence completion task using real words was developed to assess morphological awareness in young learners.

2.2.5 Dynamic Assessment

Despite the research outlined in the sections above, sentence completion tasks of morphological awareness with both real and nonsense words pose several challenges, especially for young children. Often, ceiling effects (Mahony, 1994) or floor effects (Casalis

& Louis-Alexandre, 2000) prevent analysis, with floor effects being common for less frequent morphemes in young children during pre-school/first grade (Berko, 1958). Also, it can be difficult to dissect the contributions of various underpinning skills (such as syntax, phonological awareness, comprehension, vocabulary) in arriving at the correct morphologically complex word. In turn, this poses challenges for intervention (i.e., which aspect of morphological analysis to focus on during teaching).

Dynamic assessment of the sentence completion task is a novel and valuable method to counteract these challenges. Dynamic assessment is a method of both assessing and developing literacy skills in children. The assessment is based on the Vygotsky (1978) concept of the Zone of Proximal Development whereby the test administrator interacts with the learner, to assess their knowledge and ultimately produce favourable change (Lidz, 1995).Vygotsky argued that it is just as worthwhile to measure the potential of a child as it is to measure their actual level of development.

Applying this reasoning to dynamic assessment, the task administrator must work closely with the participant to arrive at the correct answer under the guideline of predetermined prompts. The participant is asked the question and if unable to provide a correct answer, specified prompts are given in a set order until the question may be successfully answered (Spector, 1992). These prompts may also be aligned to skills that theoretically underpin the ability to answer the question. Dynamic assessment provides children with graduated prompts and therefore produces a range of scores. Also, through showing which prompt is effective at leading the child to a correct response, it enables deeper insight into the child's language profile, which may highlight specific strengths and weaknesses.

Importantly, it reduces the risk of ceiling effects by allowing the researcher to provide more challenging items than during a static task (i.e., requiring no feedback) as they know that less skilled participants will be aided by prompts. Concurrently, floor effects are minimised by graduated prompts, which align to the child's learning potential, rather than their absolute knowledge at that time. For example, if they can't do an item first time, they are provided with assistance until they arrive at the correct answer. Thus, dynamic awareness is uniquely able to test both high achieving participants (Calero et al., 2011) as well as participants with language impairments (Hasson & Botting, 2010) and young children (Tzuriel, 2000). Moreover, dynamic assessment provides a buffer against language test bias, whereby incorrect answers due to cultural unfamiliarity may be assuaged by further information in the contents of the scaffolds. It follows then that this might also be useful for young children who might not understand initial instructions (Peña et al., 2001). Finally, it is particularly useful for younger primary school children and children with language difficulties as it provides a documented indication of performance on each of the prompts, which may inform more specific intervention (Bridges & Catts, 2011).

Dynamic assessment has been employed for a wide range of language and literacy skills including English as a Foreign Language (EFL) (Kozulin & Garb, 2002), word learning (Camilleri & Botting, 2013), and phonological awareness (Cunningham & Carroll, 2011). For example, Hamavandi et al., (2017) found that a dynamic assessment task of morphological awareness significantly predicted reading outcome over and above a corresponding static task in EFL learners. They concluded that the administrator was able to assess the individual learning level of each participant through the provision of up to ten increasingly helpful prompts.

Importantly, dynamic assessment is useful for understanding the child on an individual level, and so is a very important tool for those whose knowledge might be underestimated such as children that are very young, from low socio-economic backgrounds, EFL learners, and that have developmental difficulties (Tzuriel, 2000). This might be a particularly useful tool for testing morphological awareness as some researchers assert that the explicit morphological awareness might not be evident in children under six (Feldman, 2013). Dynamic assessment then, with its range of prompts, would be ideal for tapping the potential for children's development of morphological awareness if not yet attained.

However, surprisingly, there are still very few studies that have investigated morphological awareness in young children using dynamic assessment, or indeed static assessment (for exceptions see Berko, 1958; Carroll & Breadmore, 2018). The following section outlines previous studies that have used dynamic assessment to measure morphological awareness and highlights shortcomings that the current study's assessment has aimed to address.

2.2.6 Previous studies: Dynamic assessment of Morphological Awareness

Larsen and Nippold's (2007) study was one of the first to assess morphological awareness in children using dynamic assessment. The purpose of the study was to investigate the variability in 11-12-year olds' ability to decipher morphologically complex words using morphological analysis in the Dynamic Assessment Task of Morphological Analysis (DATMA). Another primary objective was to explore this ability in relation to broader literacy skills and vocabulary.

Children were asked to define morphologically complex words such as *beastly*. If answered correctly, they were asked, *'How did you know that?'* If answered incorrectly, they were given up to six prompts to encourage the use of morphological analysis to determine the correct definition (e.g., 1- '*Tell me what the word beastly means.*' 2-'*How did you know that?*' 3- '*Does the word beastly have any smaller parts?*' 4-'*The smaller parts in this word are* beast *and* ly. *Now can you tell me what the word means?*' 5-'*Listen to this sentence and then tell me what beastly means: Jan tried to scare her brother by dressing up and acting beastly.'* 6-*'Which of these choices gives the meaning of the word beastly: a) like an animal* *b) like a plant; c) like a clown').* Interestingly, those children that responded correctly to prompt 1 were still given prompt 2 to discern whether morphological analysis was used to find the correct answer. For those children that were unable to give the correct response for prompt 1, the further prompts served as scaffolding to use morphological structure to determine the word's meaning. The Peabody Picture Vocabulary Test—III (PPVT–III; Dunn et al., 1965) was also administered to test for general word knowledge. Finally, each child's scaled score from the Reading and Literacy section of the Oregon Statewide Assessment (OSA), a standardised achievement test administered to public school children in Oregon, was obtained from the school district.

The results did reveal variability in participants' DATMA scores, ranging from 31% to 91%. Also, DATMA scores correlated positively and moderately with reading and literacy (OSA r=.50, p<.001) and vocabularly (PPVT–III r=.36, p=.01). As the OSA and the PPVT–III were strongly correlated (r=.65, p<.0001), these were combined to yield a single literacy score. Participants were then separated into low, average and high groups based on this single literacy score. Comparing these subgroups on the DATMA, a one-way ANOVA yielded a significant main effect for subgroup, with the high and average groups outperforming the low group. Larsen and Nippold (2007) used this to infer that the children in the low subgroup required a greater amount of scaffolding to determine the correct answer.

Larsen and Nippold (2007) were able to clarify how each child was using morphological analysis to decipher a morphologically complex word and delineate the extent to which adult scaffolding was necessary. However, the study had limitations. One of the key drawbacks of this study concerns the potential to make inferences about the role of morphological awareness in various literacy outcomes. The study directly investigated morphological awareness and vocabulary, however literacy measures including comprehension and word knowledge were assessed more generally from a school administered test taken prior. This test computed a single scaled score from all the literacy measures. This means that it was impossible to investigate the unique contribution of each literacy measure to morphological awareness. By amalgamating all the literacy scores into one measure, it is impossible to tease apart how morphological awareness contributes to different aspects of literacy.

There are also potential issues relating to the use of the OSA as a literacy measure. Firstly, it is unknown as to when exactly each child was administered the OSA as the investigators did not administer the test themselves. Secondly, it is reported that the test was taken most recently in Grade 5, however, the study assessed participants' morphological awreness and vocabulary in Grade six. This potentially key difference in developmental stage was not considered in discussion of the findings and it is implied that all measures are equal in this regard.

Wolter and Pike (2015) addressed this issue by investigating specific links between the DATMA and reading and spelling. Further, they explored whether morphological awareness contributed to variance in reading and spelling beyond the contribution of vocabulary and phonemic awareness.

The design of the study was based on the task in Larsen and Nippold (2007) described above but was adapted for 8-9-year old children. Children were required to define a set of 16 morphologically complex words and were provided prompts as scaffolds. This task was called the DAPMA. Results indicated that the morphological awareness task correlated significantly with three of the four literacy measures (reading comprehension, sight word reading and spelling) with reading comprehension having the strongest correlation. This study was important in that it further investigated unique contributions of morphological awareness to language and literacy measures. Furthermore, links were found between morphological awareness and reading comprehension in particular, above and beyond contributions of vocabulary and PA. This is a key finding as it suggests that participants may have been using morphological analysis strategies specifically to determine the definitions.

However, again there were key issues. Participants were only required to refer to one of the morphemes in their definition to be awarded full points, instead of both as required by Larsen and Nippold (2007). Another constraint was that most of the words in the standardised spelling task and the receptive vocabulary task were not morphologically complex, which limited any relationships found between those literacy measures and morphological awareness. Further, it may be argued that any links between morphological awareness and literacy that were found might have been due to orthographic and lexical representations instead of morphological awareness due to the lack of morphologically complex words in these literacy measures. For example, Cunningham and Carroll (2015) employed a spelling test for children specifically designed to assess the spelling of morphologically complex non-words with affixes (originally designed by Nunes et al., 2003). Children were awarded 'morphological points' for spelling each of the root and the affix correctly. Thus, this task was able to assess morphological analysis more specifically.

Although, Larsen and Nippold (2007) sought to further explore a more explicit understanding of morphological awareness through their prompts, further clarification is necessary regarding the extent to which children use various skills (e.g. phonological awareness) underpinning their morphological knowledge. Finally, providing verbal definitions for morphologically complex words might be too demanding for beginner readers, thereby limiting the accessibility of the task to older children.

Cunningham and Carroll (2015) addressed this issue by applying dynamic assessment to an adapted version of the Berko (1958) sentence completion task. In their study, a longitudinal design was used assessing children from seven years of age. By using this design, they were able to demonstrate that morphological awareness predicts reading comprehension; a finding that might have been otherwise undetectable in children of such a young age. Carroll & Breadmore (2018) extended this task to assess children with otitis media and children with reading difficulties, as well as younger ability matched controls. Although children with Otitis media possessed intact morphological awareness, poor readers needed more prompts to solve a dynamic morphological awareness task. These findings were interpreted as signaling a need for equivalent support in both morphological awareness and phonological awareness. Broadly, the findings also demonstrated the wide applicability of a dynamic sentence completion task in assessing children's morphological awareness over a wider ability range.

However, the studies outlined have not applied this task for very young children (in the earliest stages of literacy acquisition) in a way which may then elucidate the longitudinal development of morphological awareness, and its influence on later literacy skills. Further, in both studies, non-words were used. As discussed above, using real words may tap semantic knowledge which is an important aspect of morphological awareness (Carlisle & Stone, 2005). Further, this cue may be even more important for younger children. Therefore, there is still a gap in the literature as to an appropriate dynamic task of morphological awareness for children in their first year of school.

2.2.7 Present Experiments

Dynamic awareness has been shown to provide rich linguistic data, which allows access to the underpinnings of children's language abilities (Bridges & Catts, 2011). As evidenced in the studies discussed above, scaffolding may be useful as an immediate learning tool for children as well as an intervention tool for clinicians to assess specific areas of difficulty. In the current study, new dynamic task of explicit morphological awareness for young children is presented. The task adds to existing assessment tools in several ways:

Each prompt is underpinned by a specified skill in order to assess which information best contributes to achievement of the correct response (see flowchart in 2.3.3 Experiment 1 Methodology).

Very young 4-5-year-old children (with limited literacy skills) were tested to elucidate explicit morphological awareness before significant literacy instruction, which it may not be possible to tap by static tasks.

The purpose of the current chapter is to present the development and validation of a novel dynamic assessment of morphological awareness suitable for young children. I present two experiments. The first describes extensive piloting and development of the task during a free science event in 2016 (experiment 1). The second describes validation of the final task during another free science event a year later in 2017 (experiment 2).

The most significant outcome of the pilot was the decision to create prompts which are each underpinned by skills used in solving morphological awareness tasks, namely semantic strategy, explicit morphological awareness, phonological awareness, and repetition.

2.2.8 Theoretical Basis for the Prompts

In the following section, I will provide a rationale for the prompts used based on underpinning skills due to the varied nature of morphological awareness (Carlisle & Feldman, 1995). Morphological awareness involves processes in phonemic, syntactic and semantic skills and the prompts were designed to tap these skills. The prompts provided increasing support in order to gauge the level of support necessary for each child to produce the correct answer for each item. Additionally, each prompt was underpinned by a theoretically important skill. That is, in order for the child to make use of the prompt, a specific skill had to be accessed (see flowchart in 2.3.3 Experiment 1 Methodology).

Prompt 1 taps explicit morphological awareness skill by asking the child to generalise a morphological principle (e.g., *what do we add when there are lots of something-*

plurality rule). It supports the child by providing clues as to the morphological rule underlining the target word. This prompt provides the least scaffolding as it requires the child to think metalinguistically about the use of morphology in their language. Selby (1972) found that the development of most morphological rules shows steady improvement from the age of four, reaching ceiling at 12. Derivation and comparative/superlative were exceptions and developed later and slower than others.

Prompt 2 taps morphological analogy by providing another similar scaffold sentence which ends with a missing morphologically complex word that is grammatically related to the target morphologically complex word (e.g., carry*ing* and walk*ing* represent target word and scaffold words, respectively). The child then demonstrates morphological analogy by correctly completing the scaffold sentence and using this as the basis to correctly infer the target morphologically complex word. This prompt supports the child because the scaffold morphologically complex words have been designed to be more frequent and of shorter word length than their target counterparts. Thus, this prompt provides further context that might be better understood by the child and extrapolated to the target. The use of this prompt is supported by Ram et al. (2013) who found that children were better able to define a low-frequency morphologically complex word embedded into a sentence than in isolation. In line with this, children in the present studies were provided with additional contextual support and morphological cues from the scaffold sentences.

Prompts 3, 4 and 5 provide increasing levels of phonological support including segmentation, blending and isolation. Within this task though, the constituents themselves are morphemes and not phonemes. Isolable morphemes differ from isolable phonemes in that morphemes in isolation convey meaning which phonemes do not (Fowler et al., 1995). For example, the individual phonemes in pat (p-a-t) might not hold much significance in isolation but the morphemes in helper (help-er) each convey meaning individually. As mentioned previously, morphological awareness may be considered to be a comprehensive index of literacy ability as it taps various skills (Carlisle & Feldman, 1995). Although the constituents involved are morphemes, tasks which tap these skills have been shown to overlap greatly with phonological ability. Casalis et al., (2004) investigated isolation, blending and segmentation of morphemes and phonemes in children with and without dyslexia. Children with dyslexia were found to have specific deficits in these skills for both morphemes and phonemes suggesting inter-dependency between morphological and phonological segmentation skills. In contrast, these children were no different from reading-matched controls in their performance on a morphological awareness sentence completion task. Therefore, I argue that these tasks isolate the phonological component of the multifaceted morphological awareness.

In the present study, prompt 3 taps isolation, segmentation and blending skills in phonological awareness. In this prompt, the child is provided with the correct morphologically complex word (e.g., nic*er*). The child must then segment this scaffold word into its base and affix (e.g., *nice+er*), isolate the affix to separate it from the scaffold base (e.g. *-er*), and then blend the affix with the target base (e.g., *bigg+er*) to identify the correct morphologically complex word (e.g., bigger). This prompt provides support by providing a phonological analogy for the child to infer from (e.g., *nicer* to *bigger*).

Prompt 4 taps isolation and blending skills in phonological awareness. For this prompt the child is given the constituent morphemes with vocal stress on the affix (e.g. *-er*) and asked what sound was added. Therefore, the prompt provides the child with phonological analogy as well as segmentation and requires the child to isolate the affix and blend with the target base.

Prompt 5 taps blending in phonological awareness. The child is provided with support by being told what sound is added, e.g., ‘*we add an -er sound*’ (isolation) and having the affix emphasised, e.g., ‘this book is even bigg-*er*’ (segmentation). The child is then required to blend the target base with the affix, e.g., ‘this toy is even nice…’.

Prompt 6 provides the whole correct sentence including the target morphologically complex word and requires the child to repeat. This then taps the child’s ability to hold the information in their verbal memory and re-produce the target. This prompt provides the most support. The inability to identify the correct response, given the final prompt, might imply some sort of impairment in working memory indicative of language disorder (Gathercole & Baddeley, 1990). Given that the sample studied were of typically developing children, very few to no cases were expected in which prompt 6 does not elicit the correct response.

Importantly, it should be noted that although these prompts have been denoted as tapping various underpinning skills, they all more generally represent morphological awareness on a global level.

2.3 Experiment 1: Task Development

In experiment 1, described below, the task was developed and assessed. In experiment 2, which follows, the task was piloted on the target age group (4-5 years old).

2.3.1 Feasibility Objectives

A pilot study was completed to assess the dynamic assessment of morphological awareness for several reasons. Firstly, due to the pilot being carried out with participants of a wide range of ages (3-10 years), it was possible to assess the level at which children of a wider age range were able to complete the task. The age range was wide due to testing of children who attended an event held at Coventry University (more information provided in 2.3.3.1 Participants).

Secondly, it also served to further develop the task as it was being administered on children, providing immediate feedback and improvement. Therefore, the actual form of the task, prompts and stimuli changed over the course of testing. Finally, analyses were carried out on the task to assess whether it correlated with several literacy and language measures, including vocabulary, reading comprehension, word reading and phonological awareness, providing a measure of validity.

2.3.2 Feasibility Criteria

There were three feasibility criteria for the task development experiment. First, for the dynamic assessment task to correlate with at least one measure of language/literacy. Second, the children should be able to perform the task without floor effects. Finally, internal consistency reflected by Cronbach's alpha should be good (i.e., above Cronbach's alpha =.80). If these three criteria were achieved the final task would be validated with a validation study (i.e., experiment 2).

2.3.3 Experiment 1 Methodology

2.3.3.1 Participants

Children were tested at the Coventry Young Researchers event. This event was hosted at Coventry University, UK and advertised to children in Coventry and surrounding areas. Children were able to enjoy scientific activities as well as participate in various studies by Psychology researchers at Coventry University. All children were accompanied by their parents. The event lasted from August 1st, 2016 to August 5th, 2016 and was aimed at children ranging in age from three to twelve. Due to this, the children tested in this pilot span a wide age range from 3-years old to 10-years old. Ethical approval was gained from the Health and Life Sciences Research Ethics Committee at Coventry University prior to recruitment and data collection. Written consent was obtained from parents. Children provided oral assent and were reminded of their right to withdraw in child appropriate language.

Data was collected from 50 children (mean age= 5 years, 10 months; SD=1.34 months). Twenty-three of them (46%) were female and 27 were male. Final analysis was carried out on data from 47 children. Three children did not complete the task due to refusal. The mean age of the participants included in analysis was 6 years, 5 months (SD=15.87 months). Twenty-three of the final sample (48.9%) were female and 24 were male.

2.3.3.2 Background Measures

Tests were administered individually to participants in a quiet area within Coventry University library. Children were tested in three separate sessions (on the same day) for the following skills: 1) vocabulary and literacy measures 2) phonological awareness and 3) morphological awareness (the pilot task).

Vocabulary. Receptive vocabulary was tested using the British Picture Vocabulary Scale: Third Edition (BPVS3; Dunn & Dunn, 2009) according to the instruction manual. For each item, the investigator said a word which corresponded with one of four pictures. The child was required to point to the picture which best represented the spoken word.

Literacy Measures. The letter-sound knowledge test from the York Assessment of Reading for Comprehension (YARC; Snowling et al., 2009) was administered according to the instruction manual, to assess the development of pre-reading skills in children. Children were asked to provide the corresponding sounds for the 26 letters of the alphabet as well as for 2 vowel digraphs and 4 consonant digraphs.

Next, the ability to read printed words was tested using two subtests of the Test of Word Reading Efficiency - Second Edition (TOWRE-2; Torgesen et al., 2012) according to the instruction manual. Firstly, the Sight Word Efficiency (SWE) subtest measured the number of words the children could correctly pronounce in 45 seconds from a vertical list of real words. Next, the Phonemic Decoding Efficiency (PDE) subtest measured the number of non-words the children could correctly pronounce in 45 seconds from a vertical list of non-words.

Phonological Awareness. Participants were tested on their phonological awareness using two subtests from the YARC (Snowling et al., 2009) according to the instruction manual. Firstly, the sound isolation task tested phoneme awareness and required participants to identify and produce the initial or final phonemes of twelve monosyllabic non-words. Secondly, the sound deletion task required participants to delete a syllable or phoneme from real words, presented with corresponding pictures. For two items, children were asked to delete the first or last syllable from bisyllabic words. For the remaining monosyllabic items, children were asked to delete the initial, medial or final phoneme.

2.3.3.3 Morphological Awareness Task Development

A dynamic assessment of morphological awareness was developed using a sentence completion paradigm.

Item Design. Twenty items including two practice items were selected from a different static morphological awareness task which had been administered with 30 pre-school children (Breadmore & Deacon, 2021, manuscript in preparation). Items were selected that had garnered correct responses from at least 10% of the participants (three out of 30), but no more than 50% of participants (15 out of 30). This was done in order to extract the more difficult items which would facilitate the use of prompts and avoid floor and ceiling effects. For the very young children studied in this investigation, morphological awareness is emergent and thus care was taken to select easier items such as the agentive suffix -er (e.g., helper), the-y adjective suffix, and the plural suffix -es (e.g., noses) (Derwing, 1976). This resulted in 18 items, 16 inflections and two derivations.

Scaffold items were then created for each test item and selected to be of higher frequency, shorter in length, and from the same semantic and morphological category as their corresponding target words (see Appendix A for list of items and their frequencies). Frequencies were determined from the SUBT-LEX Cbeebies word frequencies corpus (Van Heuven et al., 2014). The idea was that children would make an analogy between the scaffold and target item that would allow them to correctly identify the target response. As the scaffold items were selected to be ‘easier’ than the targets, the intention was that by identifying the correct response for the scaffold, this would facilitate a correct response to the target item. For example, the scaffold word *bigger* was determined to be more frequent than the target word *nicer*. Table 1 shows the list of all the target items administered along with the corresponding scaffold items which were used in the prompts.

Table 1.

List of Target Items and Their Accompanying Scaffold Items

Target item	Corresponding Scaffold item	Transformation
The word is count. They can count. Yesterday, they ***counted***.	PRACTICE	+/Id/ +ed regular past tense
The word is listen. They like to listen. See how well they are ***listening***.	PRACTICE	+ing present progressive
The word is nose. This is my nose. These are their ***noses***.	The word is house. This is my house. These are their ***houses***.	+/z/ +s plural noun
The word is jump. This girl likes to jump. Last week, she ***jumped***.	The word is dance. This boy likes to dance. Last week, look how much he ***danced***.	+/t/ +ed regular past tense
The word is cry. Babies cry. Yesterday, this baby ***cried***.	The word is try. At school, children try. Yesterday, this boy ***tried***.	+/d/ +ed regular past tense
The word is stop. The rain won't stop. I like it when the rain ***stops***.	The word is play. My friend won't play. I like it when my friend ***plays***.	+/s/ +s regular present tense
The word is brush. This boy does a lot of brushing. Look how he ***brushes***.	The word is push. Mum does a lot of pushing. Look how she ***pushes***.	+/Iz/ +s regular present tense
The word is nice. This toy is nice. This toy is even ***nicer***.	The word is big. This book is big. This book is even ***bigger***.	+er comparative
The word is small. This book is small. This book is the ***smallest***.	The word is new. This car is new. This car is the ***newest***.	+est superlative
The word is ankle. It went around her ankle. Then around both ***ankles***.	The word is hand. She held on with one hand. Then she held on with both ***hands***.	+/z/ +s plural noun
The word is help. Doris likes to help people. Doris is a ***helper***.	The word is think. Mary likes to think. Mary is a ***thinker***.	+er/+or person connected with,
The word is carry. He could not carry anything else. See how much he was ***carrying***.	The word is walk. He could not walk anymore. See how much he was ***walking***.	+ing present progressive
The word is lady. This badge belongs to the lady. The badge is the ***lady's***.	The word is teacher. This pen belongs to the teacher. The pen is the ***teacher's***.	+/Iz/ 's posessive
The word is glow. Starts glow in the sky. Last night they ***glowed***.	The word is roar. Lions roar. Last night they ***roared***.	+/d/ +ed regular past tense
The word is waddle. The ducks waddle through the field. Look how that duck ***waddles***.	The word is climb. The monkeys climb the tree. Look how that monkey ***climbs***.	+/z/ +s regular present tense
The word is cat. This cat has a tail. This tail is the ***cat's***.	The word is dog. This dog has a bowl. The bowl is the ***dog's***.	+/s/ 's posessive
The word is fetch. This dog likes to fetch. See all the things he ***fetches***.	The word is scratch. This cat likes to scratch. See all the things she ***scratches***.	+/Iz/ + s regular present tense
The word is bushy. This fox has a bushy tail. That fox's tail is even ***bushier***.	The word is spotty. This fox has spotty skin. That frog's skin is even ***spottier***.	+er comparative
The word is dirt. Sam was covered in dirt. Sam looked ***dirty***.	The word is cloud. The sky was full of clouds. The sky was ***cloudy***.	+ity/+ty state of,
The word is care. Mum said "Take care crossing the road. Be ***careful***."	The word is forget. This Mr. Man forgets a lot. Dad says "He is ***forgetful***".	+ful full of,

Procedural Design. On each item, children were shown a pictorial representation of the target word for context. Children were given the root word (e.g., '*the word is **nice***'), followed by the root word in a sentence (e.g., '*this toy is **nice***') and finally a third sentence which ended with a pause, prompting the child to produce the target word, which was a morphologically complex (inflection or derivation) word containing the root (e.g., '*this toy is even…' [nicer]*).

Children were given up to five graduated prompts (involving the scaffold item), following the lack of a correct response to the initial question. A pictorial representation of the scaffold was provided. Following each prompt, the initial question was repeated (target sentence completion), giving the child the opportunity to provide a correct response. The first prompt rephrased the question, replacing the target word and picture with its corresponding scaffold item and a pictorial representation. The second prompt repeated the question using the scaffold item, this time providing the correct answer. The third prompt provided the child with an explanation of how to derive the correct response using morphological analysis (a child-friendly explanation of the morphological rule) as well as verbally emphasising the affix. The fourth prompt explicitly provided the correct affix. The fifth prompt provided the child with the correct answer and asked them to repeat. The flowchart in Figure 2 provides a summary using the target item *nicer* as an example.

For each item, two dependent variables were recorded; accuracy of response without prompts and (when the initial response was an error, akin to what would be the response in a static task) and the number of prompts necessary for the correct answer to be achieved. Before starting each item, children were given standard instructions and accompanying pictures. The following is an example of the procedure using the target word *bigger* and the scaffold *nicer* (accompanying example illustrations may be found in Appendix B):

First, the investigator provided the child with instructions and 2 practice items. '*We're going to play a word game. I will say a word, and then read you a sentence. I'd like you to finish the sentence using a longer form of the word. Don't worry if you don't get the answer right first time round as I will help you. We'll have two practices first. The word is count. They can count. Yesterday they counted. So count was the word, and counted was the answer that finished the sentence. The word is listen. They like to listen. See how well they are listening. So listen was the word, and listening was the answer that finished the sentence. OK, ready to try some real ones*?

Next the investigator asked the child the target question: '*The word is nice. This toy is nice. This toy is even …*'. If the child responded with the target word *nicer,* the investigator proceeded with the next test item. If the child was unable to provide the correct answer, the investigator read the first prompt using the scaffold *bigger*.

Prompt one: '*The word is big. This book is big. This book is even ...*' If the child responded with the correct scaffold word *bigger,* the investigator re-tested them with the target question as shown above. If this was then answered incorrectly, the investigator read prompt two. However, if this was answered correctly, the investigator proceeded to the next test item. If the child was unable to provide the correct answer for prompt one, the investigator proceeded to prompt two.

Prompt two: '*This book is big. This book is even bigger.*' The investigator then read the target test question. If the child responded with the correct target word *nicer,* the investigator proceeded to the next test item. If the child was unable to provide the correct answer for prompt one, the investigator proceeded to prompt three.

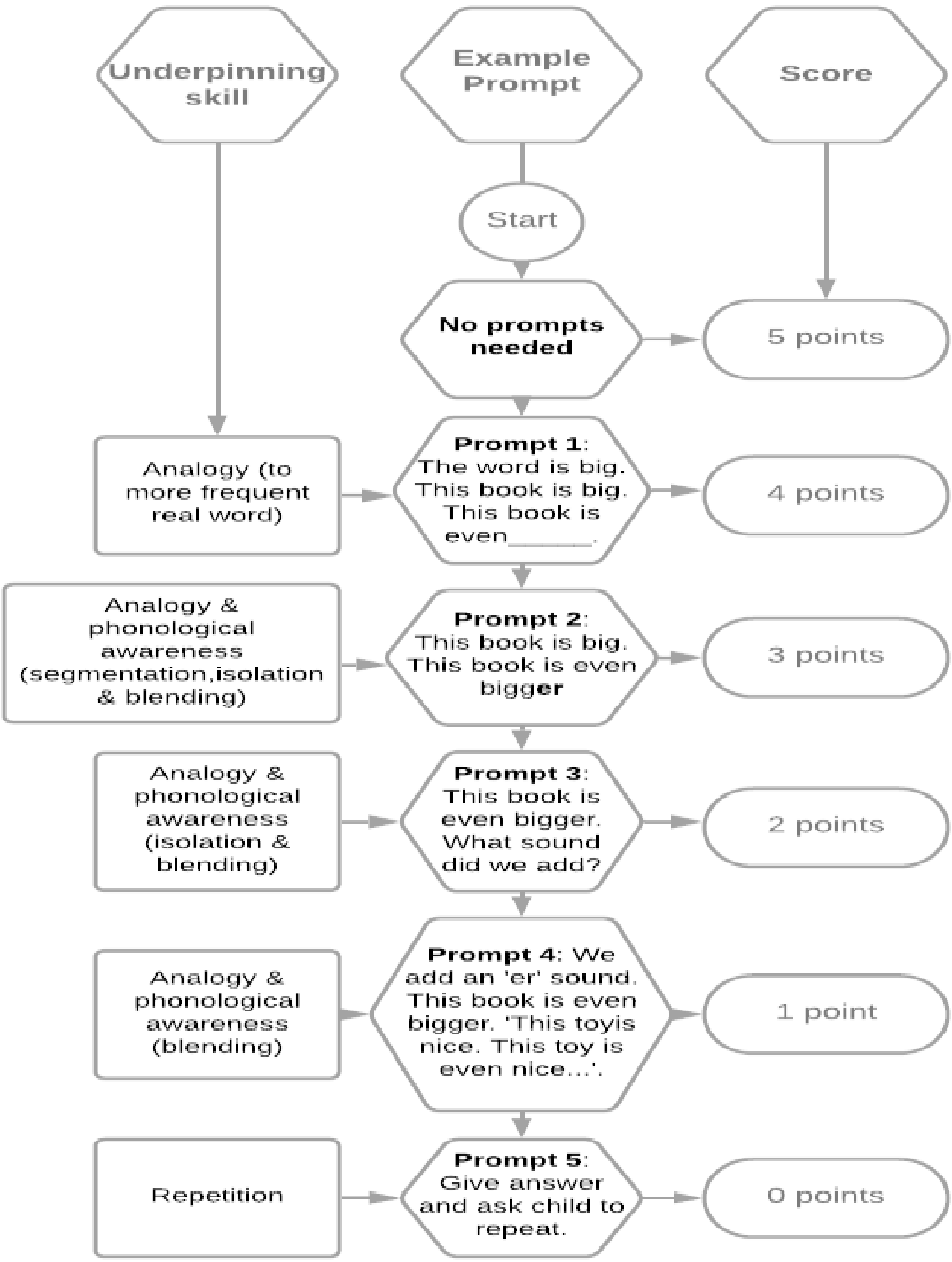
Prompt three: '*This book is even bigger. What sound did we add?*' If the child responded with the correct affix 'er' the investigator re-tested them with target question. If this was then answered incorrectly, the investigator read prompt four. However, if this was answered correctly, the investigator proceeded to the next test item. If the child was unable to provide the correct answer for prompt three, the investigator proceeded to prompt four.

Prompt four: '*We add an er sound. This book is even bigger. This toy is nice. This toy is even nice…*' If the child responded with the correct affix 'er', the investigator proceeded to the next test item. If the child was unable to produce the correct response, the investigator read the final prompt five.

Prompt five: '*This toy is nice. This toy is even nicer.*' The child was given the correct answer and then asked to repeat it. The investigator then proceeded to the next item, irrespective of the outcome.

Figure 2.

Flowchart Showing Order of Prompts along with their Underpinning Skills and Scores for the Dynamic Morphological Assessment used in Experiment 1



Changes made to items and procedure during the current pilot. As this was a pilot study, changes to the morphological awareness task were made over the course of the five-day event. On the first day, two of the twenty prepared items were modified to be used as practice items.

On the second day, prompts three and four were combined into a single prompt (i.e. explaining the morphological rule and explicitly giving the required affix). Using the word carrying as an illustration again, this resulted in: '*When someone was doing something, we add a sound to the end of the word. See how much he was walking. We add an 'ing' sound. He could not carry anything else. See how much he was carrying.*' Children were reminded to use one word for the correct target response (i.e. 'jumped' and not 'was jumping') to prevent responding to past tense items with the past continuous tense. For the comparative adjectives, the word *even* was placed before the target response (e.g., *this toy is even nicer*) to place more emphasis on the comparative component. Items that included a word after the target response were modified to ensure that the target word was the final word (i.e., 'you can tell he never brushes it' was changed to 'you can tell he never brushes') in order to draw more attention to the target. For one item, a cartoon image depicted a parent pushing their child on a swing. This was replaced with a more realistic photograph of a mother pushing her daughter on a swing. For another item, where a superlative adjective (biggest) was the target word, the corresponding image was of a large book and a small book. This was modified to include three books of diminishing size which better depicted the superlative adjective. Finally, on another item, there was an image of a policewoman depicting 'the badge is the lady's'. This was changed to a lady in a suit with a badge to avoid confusion – namely children saying 'the badge is the policewoman's'.

On the third day, the target and scaffold affixes were emphasised on prompts three and four. The fifth prompt was changed from providing children with a written demonstration of the target response to providing the children with the answer orally and asking them to repeat it. For certain tense-related items, if the child used the wrong tense in their answer, they were reminded of when the event took place. Finally, an instruction sheet was created to standardise the process.

On the fourth day, the item which contained a picture of cartoon dog with items at his feet was replaced with a picture of a dog fetching things to better correspond with the present tense of the target word *fetches*.

On the fifth day, the item which contained the picture of a cartoon cat with a long tail was changed to a picture of a real cat as children were getting distracted by the cat's tail being long. Instead of saying 'this tail is the cat's', some children were saying 'this tail is long'.

2.3.4 Experiment 1 Results

Each participant's dynamic morphological awareness score was calculated by totalling the prompt scores across all the items. The maximum score possible was 90 corresponding with a maximum score of 5 for each item across the 18 items. The static portion was derived from the dynamic task by attributing a score of 1 when the child determined the target response the first time the question was asked (without prompts), and a score of 0 if the child required any prompts. Each participant's static score was calculated by totalling the number of items which required no prompts to achieve the correct answer for a possible maximum score of 18.

The reliability for the dynamic morphological awareness measure was Cronbach's alpha =.80. This suggests that the dynamic assessment has high reliability. The mean and standard deviation were M= 81.13 and SD=10.51. The skewness value for the morphological awareness task was -2.12. There was no significant difference between morphological awareness means for girls (M=80.22; SD=10.76) and boys (M=82; SD=10.43); t (45) =-.58,

p=.57. Likewise, there was no significant difference between morphological awareness means before implementation of changes (M=79.92) and after (M=81.59); t (45) =-.48, p=.63.

Table 2 shows the total means, ranges and standard deviations for the dynamic assessment of morphological awareness, the static portion of the dynamic assessment of morphological awareness, phonological awareness, vocabulary, real word reading and non-word reading. Scores for the standardised tasks were generally quite high, perhaps reflecting the ability of children that took part in the Coventry Young Researchers event. These high scores may also limit the variability of the data and attenuate any effects with MA.

Table 2.

Means, Ranges and Standard Deviations for Performance on Static and Dynamic Morphological Awareness (MA dynamic and MA static), Literacy and Vocabulary Scores

Variables	Minimum	Maximum	Mean	Std. Deviation
MA dynamic	43	90	81.13	10.51
MA static	5	18	14.28	3.14
Phonological awareness standardised score	71	114	107.47	9.14
Phonological awareness raw score	2	24	17.51	5.99
Vocabulary standardised score	77	133	106.05	11.88
Vocabulary raw score	36	139	93.80	23.72
Letter-sound knowledge standardised score	75	124	108.18	11.63
Letter-sound knowledge raw score	1	17	14.02	5.13
Real word reading standardised score	99	144	120.57	12.26
Real word reading raw score	8	82	50	20.73
Non-word reading standardised score	102	145	122.52	10.88

Variables	Minimum	Maximum	Mean	Std. Deviation
Non-word reading raw score	6	52	28.85	13.01

Next, in order to inform the prospective stimuli for the main study, the usefulness of each prompt for gaining the correct answer was determined by counting the number of times a correct answer was produced after each prompt across all items and participants. This is shown in Table 3.

Table 3.

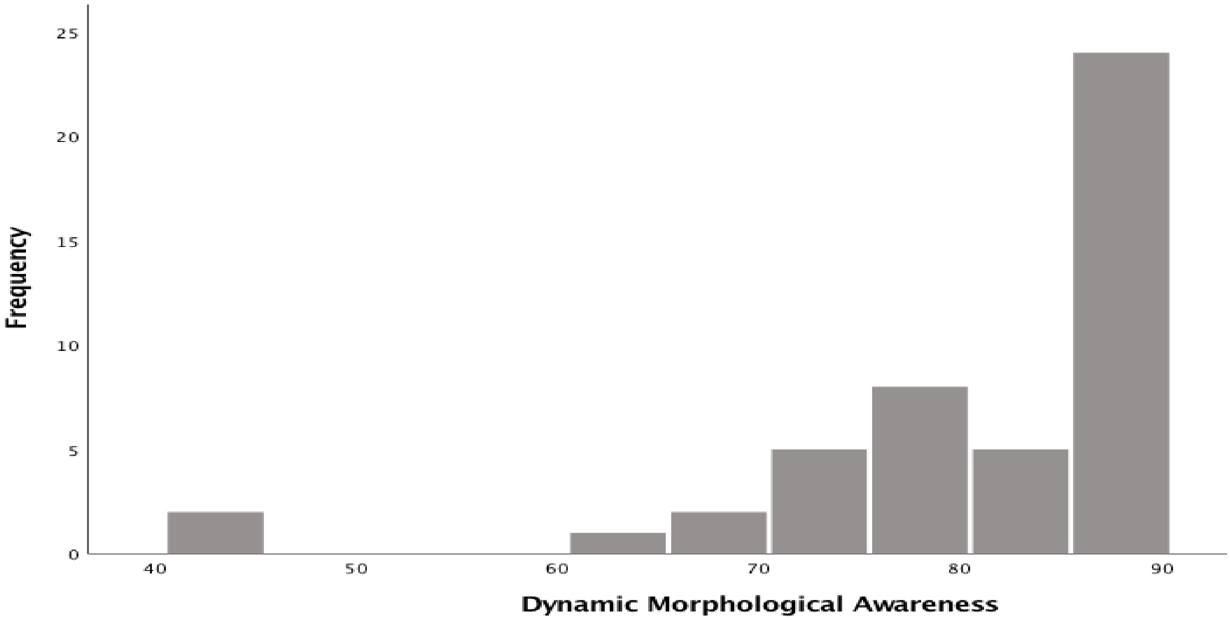
Usefulness of Each Prompt for Producing the Target Response

Prompt number	No prompts	Prompt one	Prompt two	Prompt three	Prompt four	Prompt five
Number of correct responses	678	61	54	9	41	12

Figure 3 shows dynamic morphological awareness scores across all participants. The distribution was negatively skewed (skewness=-2.12), indicating that many of the children were performing at ceiling.

Figure 3.

Histogram of Dynamic Morphological Awareness Scores Across all Participants



Pearson's r correlations were performed between the morphological awareness task, the static version of the morphological awareness task, and the six literacy and language measures (vocabulary, single word reading, non-word reading, letter-sound knowledge, and phonological awareness), controlling for age. Raw scores were used for the standardized assessments. These correlations are given in Table 4 and show that the dynamic morphological awareness task correlated more strongly with the other measures than did the static version of the morphological awareness task. The dynamic morphological awareness task correlated moderately and significantly with the static morphological awareness portion, r =.91, p <.001.

Table 4.

Partial Correlations Between the Dynamic Morphological Awareness (MA)Task, Static Morphological Awareness (MA), Vocabulary and Literacy Measures, Controlling for Age

Variables	1	2	3	4	5	6	7
1. MA dynamic	-	.91**	.73**	.59**	.41**	.46**	.36*
2. MA static		-	.56**	.49**	.36*	.35*	*.26*
3. Phonological Awareness			-	.34*	.66**	.61**	.59*
4. Vocabulary				-	*.21*	.62**	.56**
5. Letter-sound knowledge					-	-*.26*	-*.08*
6. Real word reading						-	.91**
7. Non-word reading							-

Note. All correlations significant at p < .05 marked by an asterix (*). All correlations significant at p < .01 marked by two asterixes (**). Non-significant correlations are in italics.

Finally, correlations were also performed between dynamic morphological awareness, static morphological awareness and the literacy measures, controlling for phonological awareness and age. This was done in order to partial out the effect of the contribution of phonological awareness to the morphological awareness task in its relationship to other variables. As shown in Table 5, vocabulary was the only variable which correlated significantly with morphological awareness dynamic (r=-.54, p<.01) after partialling out both age and phonological awareness. This would suggest that morphological awareness is likely to have a stronger and purer association with vocabulary than non-word reading, real-word reading and letter-sound knowledge.

Table 5.

Correlations Between Dynamic and Static Morphological Awareness and Literacy/Vocabulary, controlling for Phonological Awareness and Age

Variables	1	2	3	4	5	6
1. MA dynamic	-	.90**	.54**	*-.14*	*.03*	*-.14*
2. MA static		-	.38*	*-.01*	*.02*	*-.11*
3. Vocabulary			-	*-.02*	.55**	.47**
4. Letter-sound knowledge				-	1.00**	-.77**
5. Real word reading					-	.86**
6. Non-word reading						-

Note. All correlations significant at p < .05 marked by an asterix (*). All correlations significant at p < .01 marked by two asterixes (**). Non-significant correlations are in italics.

2.3.5 Experiment 1 Discussion

The aim of experiment 1 was to create a Dynamic Morphological Awareness task that was both reliable and valid in assessing the Morphological Awareness of young children. Over the course of data collection, the task was continuously amended as documented in the Methodology section above. The three criteria proposed to assess the task's feasibility were all met. Internal consistency of the morphological awareness items was good with a Cronbach's alpha score of .80. Also, the task provided a wide range of scores. The task was found to correlate significantly with phonological awareness, letter-sound knowledge, vocabulary, real word reading, and non-word reading, demonstrating good validity.

Moreover, these were all found to be stronger with the dynamic score than the static score, highlighting the increased contribution of the dynamic aspect. Nevertheless, after controlling for phonological awareness, only vocabulary remained significantly correlated to the task. Also, many of the children performed at ceiling. In experiment 2, I sought to assess the task's suitability for Reception aged children (4-5-year-olds), as well as its reliability and validity in the final form.

2.4 Experiment 2: Task Validation

2.4.1 Objectives

Given the feasibility criterion, experiment 1 may be deemed as feasibility successful, having correlated moderately, significantly and positively with vocabulary, phonological awareness, and letter-sound knowledge (see Thabane et al., 2010 for a discussion on study feasibility). Over the course of the experiment 1, several changes were made to the structure of the task, and stimuli, culminating in the final task. Due to the negative skew found in the distribution, it was determined that many of the children were finding the task easy. I sought to increase variability between children as well as increase the task difficulty by including an extra prompt. Prompt 1 would precede the others and assess the children's metalinguistic understanding of the morphological rule. Thus, this prompt was deemed to require higher-level knowledge than the other prompts (see the flowchart for the final task format in 2.4.2.4 Final Dynamic Assessment of Morphological Awareness).

The primary objective of experiment 2, therefore, was to assess the validity and reliability of the task, in its final form, for Reception age children (4-5 years old). This was done by correlating the dynamic assessment task with various literacy and language measures. A correlation of $r>.60$ might reflect a strong correlation between literacy measures and morphological awareness (Deacon & Kirby, 2004). Internal consistency should again reach Cronbach's alpha=.70. Finally, the task should provide a wide range of scores, without floor effects.

2.4.2 Experiment 2 Methodology

2.4.2.1 Participants

Participants were again recruited from the annual Coventry Young Researchers event, described in experiment 1 above. However, this sample was collected from the following year's event in 2017. The event in 2017 took place from July 31st to August 4th.

Participants consisted of 40 children. Four children were excluded from analyses due to completing less than 40% of the morphological awareness task, leaving a final sample of 36 children. All but four of the remaining sample completed all the 18 items (two completed 17 items, one completed 15 items and one completed 14 items). Although the sample consisted of a wide range of ages, Reception age 4-5-year-old children was of particular interest due to their relatively low exposure to formal literacy instruction. Therefore, the sample was split according to age to verify whether the task might be particularly suited to the target age range (see Table 6). The younger group consisted of children whose ages fell within the target year group intended for the assessment (i.e., in Reception, children's ages may range from 49 months to 71 months). Thus, the children in the younger group consisted of the target age population within the above parameters. Children in the older group consisted of older children between the ages of 72 months and 106 months. As shown in the table, the mean age of the younger group was 59.38 months. Given the mid-point age (60 months) of the age range of Reception children generally, the younger group was fairly representative of this year group with regards to age.

Table 6.

Mean, Minimum and Maximum Age, and Gender Across Younger, Older and Combined Participants

	Younger (N=21)	Older (N=15)	All (N=36)
Mean age (months)	59.38 (6.75)	82.87 (10.77)	69.17 (14.48)
Minimum-maximum age (months)	51-71	73-106	51-106
Female: Male (N)	10:11	9: 6	19: 17

2.4.2.2 Procedure

The procedure was identical as in experiment 1 above. However, the task was not continuously amended as in experiment 1. Also, a prompt was added at the beginning, requiring the child to evidence knowledge of morphological rules (see the flowchart in Figure

4). Ethical approval was gained from the Health and Life Sciences Research Ethics Committee at Coventry University prior to recruitment and data collection. Written consent was obtained from parents. Children provided oral assent and were reminded of their right to withdraw in child-appropriate language.

2.4.2.3 Background Measures

Vocabulary. Receptive vocabulary was tested using the British Picture Vocabulary Scale: Third Edition (BPVS3) (Dunn & Dunn, 2009). See experiment 1 for further information.

Literacy measures. The ability to read printed words was tested using the two subtests of the Test of Word Reading Efficiency - Second Edition (*TOWRE-2,* Torgesen, Wagner, & Rashotte, 2012): Sight Word Efficiency (SWE) and Phonemic Decoding Efficiency (PDE).

Firstly, SWE subtest measured the number of words the children could correctly pronounce in 45 seconds from a vertical list of real words. Next, the PDE subtest measured the number of non-words the children could correctly pronounce in 45 seconds from a vertical list of non-words. See a further description of these tasks in experiment 1.

Phonological awareness. In order to assess phonological awareness development, the Preschool and Primary Inventory of Phonological Awareness (PIPA) was administered to participants (PIPA- Dodd, Crosbie, McIntosh, Ozanne & Teitzel, 2000). The six subsets included were Syllable Segmentation, Rhyme Awareness, Alliteration Awareness, Phoneme Isolation, Phoneme Segmentation and Letter Knowledge. Each task was administered in line with the standardized instructions.

2.4.2.4 Final Dynamic Assessment of Morphological Awareness

The task reported in experiment 2 was the same as in experiment 1 (i.e., item development and dynamic aspect) except for the addition of prompt 1 at the beginning. This prompt was added to separate those children who possessed deeper metalinguistic understanding of morphological rules. Thus, whilst there was a total of 5 prompts in experiment 1, there were 6 prompts in the final version of the task in experiment 2. A flowchart is shown at the end of this section to show the addition of the morphological rule prompt. The final task was administered as follows:

First, the investigator provided the child with instructions and 2 practice items. '*We're going to play a word game. I will say a word, and then read you a sentence. I'd like you to finish the sentence using a longer form of the word. Don't worry if you don't get the answer right first time round as I will help you. We'll have two practices first. The word is count. They can count. Yesterday they counted. So count was the word, and counted was the answer that finished the sentence. The word is listen. They like to listen. See how well they are listening. So listen was the word, and listening was the answer that finished the sentence. OK, ready to try some real ones*?

Next the investigator asked the child the **target question**: '*The word is nice. This toy is nice. This toy is even ...*'. If the child responded with the target word *nicer,* the investigator proceeded with the next test item. If the child was unable to provide the correct answer, the investigator read the first prompt.

Prompt one: '*When something is more than another, we add something to the end of the word. What do we add?*'. If the child achieved the correct response to the question, the investigator re-tested them with the target question as shown above. If this was then answered incorrectly, the investigator read prompt two. However, if this was answered correctly, the investigator proceeded to the next test item. If the child was unable to provide the correct answer for prompt one, the investigator proceeded to prompt two using the scaffold *bigger*.

Prompt two: '*The word is big. This book is big. This book is even ...*'. If the child responded with the correct scaffold word bigger, the investigator re-tested them with the target question as shown above. If this was then answered incorrectly, the investigator read prompt three. However, if this was answered correctly, the investigator proceeded to the next test item. If the child was unable to provide the correct answer for prompt two, the investigator proceeded to prompt three.

Prompt three: '*This book is big. This book is even bigger.*' The investigator then read the target test question. If the child responded with the correct target word *nicer,* the investigator proceeded to the next test item. If the child was unable to provide the correct answer for prompt three, the investigator proceeded to prompt four.

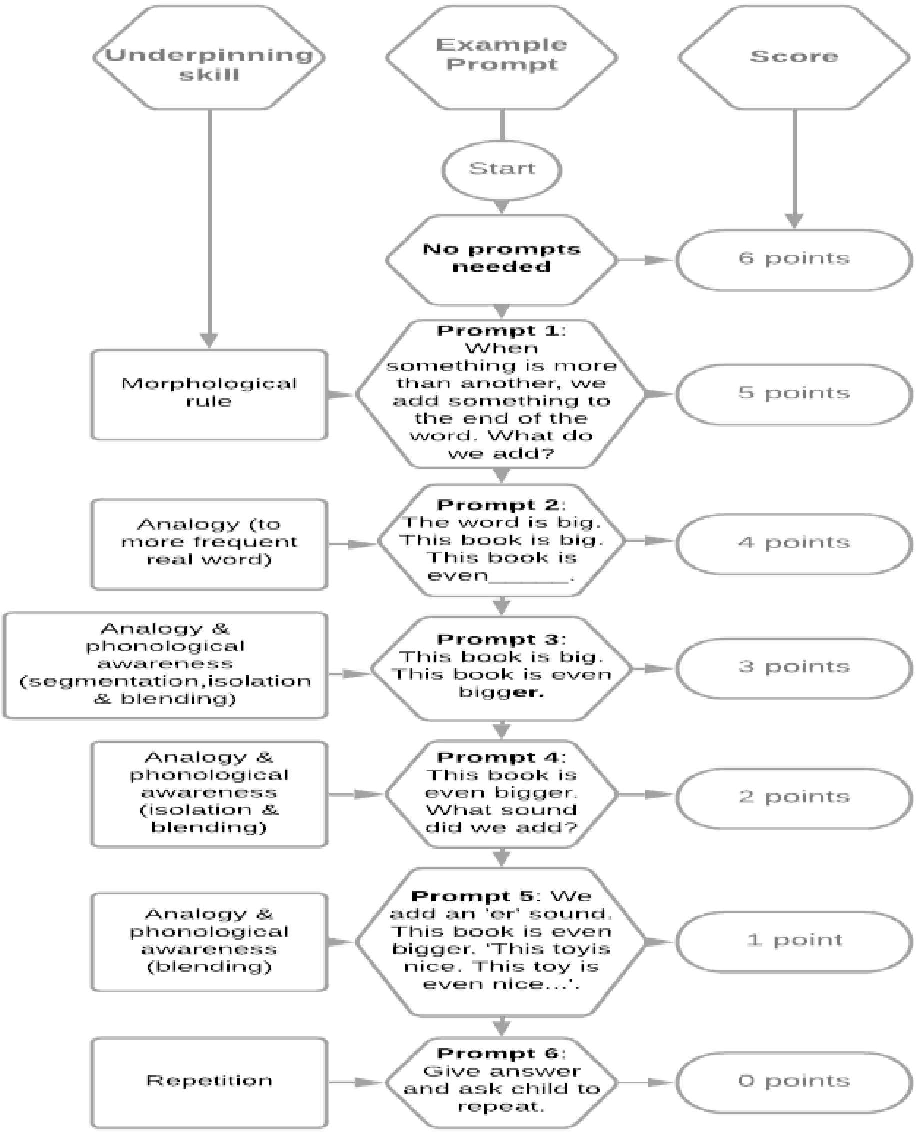
Prompt four: '*This book is even bigger. What sound did we add?*' If the child responded with the correct affix 'er' the investigator re-tested them with target question. If this was then answered incorrectly, the investigator read prompt five. However, if this was answered correctly, the investigator proceeded to the next test item. If the child was unable to provide the correct answer for prompt four, the investigator proceeded to prompt five.

Prompt five: '*We add an er sound. This book is even bigger. This toy is nice. This toy is even nice…*' If the child responded with the correct affix 'er', the investigator proceeded to the next test item. If the child was unable to produce the correct response, the investigator read the final prompt six.

Prompt six: '*This toy is nice. This toy is even nicer.*' The child was given the correct answer and then asked to repeat it. The investigator then proceeded to the next item, irrespective of the outcome.

Figure 4.

Final Dynamic Assessment of Morphological Awareness with an Example Item and its Accompanying Prompts, Underlying Skills and Scores



Note. The only change made from experiment 1 to experiment 2 was the addition of prompt 1 as shown in the flowchart above which asked the children to consider the underlying morphological rule.

2.4.3 Experiment 2 Results

Table 7 shows the total means, ranges and standard deviations for vocabulary, phonological awareness, real word reading and non-word reading. Scores for the standardised tasks were again quite high, reflecting the ability of children that took part in the Coventry Young Researchers event. These high scores may also limit the variability of the data and attenuate any effects with MA.

Table 7.

Means, Ranges and Standard Deviations for Performance on Literacy and Vocabulary Measures

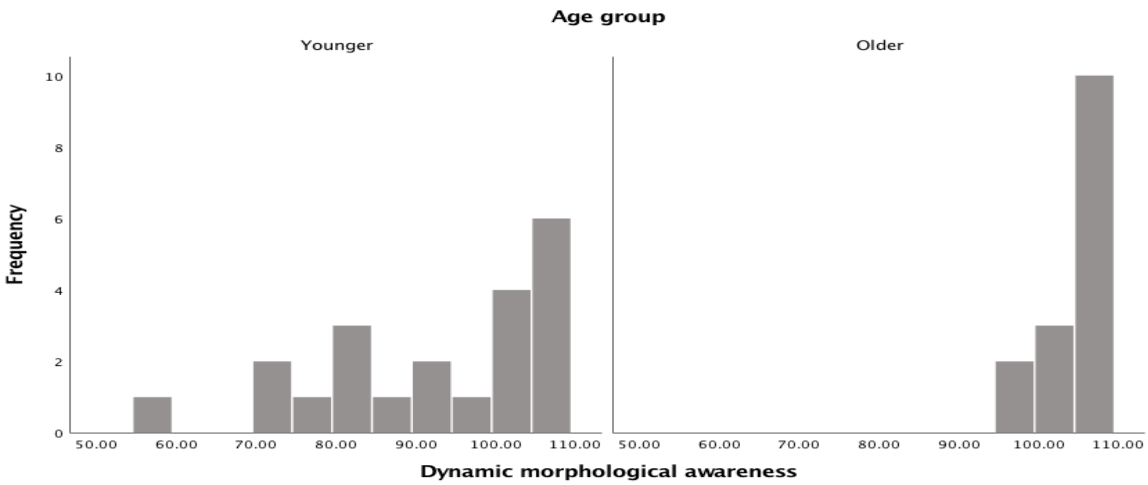
Variables	Minimum	Maximum	Mean	Std. Deviation
Vocabulary standardised score	83	127	106.25	11.83
Vocabulary raw score	34	138	90	26.65
PIPA standardised score	90	130	123.33	6.58
PIPA raw score	6	13	11.22	2.05
SWE standardised score	56	133	115.15	19.18
SWE raw score	35	76	54.29	12.14
PDE standardised score	69	141	116.31	17.26
PDE raw score	18	49	28.79	10.16

2.4.3.1 Intra-item Reliability through Item Analysis

The reliability for the 18 items of the morphological awareness measure was Cronbach's $\alpha = 0.77$, illustrating acceptable internal consistency. The skewness value for the morphological awareness measure was -1.49, indicating skewed distribution with the majority of values above the mean (i.e., fewer prompts needed for the correct answer). The skewness values for the younger participants was -.79 and for the older participants was -1.27. The sample was comprised of a wide range of children, which might have resulted in ceiling effects for the older participants (see Figure 5). This is expected as the task was designed for 4-5-year olds, as in the younger group. The lower skew value is expected in the younger group as the task was aimed at this age group. Therefore, split analyses were carried out based on participant age.

Figure 5.

Histogram for Younger and Older Participants' Frequencies of Summed Dynamic Morphological Awareness Scores



Means, totals, and standard deviations of morphological awareness scores for each participant group (older and younger) and both groups combined (all participants) are given in Table 8.

Table 8.

Mean Morphological Awareness Means, Sums, Minimums and Maximums across Younger Participants, Older Participants and Combined Participants (Standard Deviations in Parentheses)

	Younger participants	Older participants	All participants
N	21	15	36
Morphological awareness total	92.67 (14.99)	104.27 (4.03)	97.5 (12.98)
Minimum-Maximum	57-108	57-108	57-108

Note. Older participants were aged 6-8 years and younger participants were aged 4-5 years.

In terms of prompt usefulness, younger children found prompt 6 (repetition) the most useful, while prompt 1 (explicit morphology) and prompt 4 (analogy and phonological awareness-segmentation) were the least useful. Older children found prompts 1 (explicit morphology), 2 (analogy) and 3 (analogy and phonological awareness) equally most useful while the final prompt was found the least useful (in contrast with the younger children). Finally, across all the children, prompts 2 and 6 were found to be equally most useful while prompt 4 was found to be the least useful (see Table 9).

Table 9.

Percentage of Cases for Which Each Prompt Lead to the Correct Response Across Younger Children, Older Children and all Children.

	Younger children	Cumulative frequency	Older children	Cumulative frequency	All children	Cumulative frequency
No prompts	82.56	82.56	91.48	91.48	86.34	86.34
Prompt 1	0.54	83.11	2.59	94.07	1.41	87.76
Prompt 2	3.27	86.38	2.22	96.30	2.83	90.58
Prompt 3	4.90	91.28	2.22	98.52	3.77	94.35
Prompt 4	1.09	92.37	0.74	99.26	0.94	95.29
Prompt 5	2.18	94.55	0.37	99.63	1.41	96.70
Prompt 6	5.45	100	0.37	100	3.30	100

Note. Corresponding cumulative frequencies each shown in separate adjacent columns.

Table 10 shows the usefulness of each prompt according to item difficulty. Item difficulty was determined by calculating the total scores for each item across all the participants. It is possible that children use prompts differentially depending on item difficulty. This might elucidate which strategies or skills children might use for more difficult morphological awareness items compared to the less difficult ones. Indeed, the participants found prompt 3 (analogy and phonological awareness) the most useful for the easier items, although the majority of cases did not require any prompts. Participants found prompt 6 (repetition) the most useful for the more difficult items.

Table 10.

Percentage of Cases for Which Each Prompt Lead to the Correct Response Across the Less Difficult Half of Morphological Awareness Items and the More Difficult Half of Morphological Awareness Items

	More difficult items	Less difficult items
No prompts	79.25	93.42
Prompt 1	1.57	1.25
Prompt 2	5.03	0.63
Prompt 3	5.03	2.51
Prompt 4	1.57	0.31
Prompt 5	1.89	0.94
Prompt 6	5.66	0.94

As all the items were presented to participants in the same order, a correlation was carried out between the item order of presentation and mean morphological awareness score. There was a weak positive and non-significant correlation between the variables, r=0.12, p=.65. This suggests that the order of the presentation of the items did not have an effect on the morphological awareness scores.

2.4.3.2 Links to Established Measures

Due to the skew of the data and the relatively small sample size, Spearman non-parametric correlations (two-tailed) were carried out to determine any links between the dynamic morphological awareness scores (MA) and standardised scores from the British Picture Vocabulary Scale (BPVS), Primary Inventory of Phonological Awareness (PIPA), sight word efficiency (SWE) and phonemic decoding efficiency (PDE). For combined ages, morphological awareness was found to be significantly correlated with phonological awareness and vocabulary (see Table 11.

Table 11). However, morphological awareness did not correlate significantly with SWE, or PDE.

In order to carry out more specific analyses with the target age population, the analyses were then split by age. The mean morphological awareness score for older children did not correlate significantly with any of the background measures perhaps due to ceiling effects found for the older age group. Interestingly, the mean morphological score did correlate strongly and significantly with vocabulary (BPVS) and phonological awareness (PIPA) for the younger children. It is worth noting that correlations were not possible to compute between morphological awareness and the word reading measures (SWE and PDE) for the younger children. This is expected and due to a lack of data stemming from the younger group's low reading level at this age. Also, for the older children, it was not possible to compute correlations between the PIPA and morphological awareness as many of them were above the age range of this assessment. Correlations for the Morphological Awareness task and each of the background measures are provided in Table 11.

Table 11.

Correlations for Dynamic Morphological Awareness (dynamic MA) and each of Vocabulary (BPVS), Word and Nonword Reading (SWE, PDE), and Phonological Awareness (PIPA) across the Younger Group, Older Group and all Participants Combined

	Dynamic MA and BPVS	Dynamic MA and PIPA	Dynamic MA and SWE	Dynamic MA and PDE
Younger group	r (19)=.79, p<.001	r (10)=.62, p=.02		
Older group	r (13)=.46, p=.09		r (13)=0.36, p=.19	r (13)= 0.24, p=.40
Combined group	r (33) =.75, p<.01	r (10)=.62, p<.05	r (14) =0.39, p=.13	r (14) =0.32, p=.23

2.4.3.3 Dynamic Contribution

Correlations were carried out between the static morphological awareness results and the literacy and language measures (see Table 12). The static portion was derived from the dynamic task by attributing a score of 1 when the child determined the target response the first time the question was asked (without prompts), and a score of 0 if the child required any prompts.

Table 12.

Correlations between the derived static portion (SP) and dynamic morphological awareness (Dynamic MA), BPVS, PIPA, SWE and PDE across combined age groups, the younger group and the older group

	SP and Dynamic MA	SP and BPVS	SP and PIPA	SP and SWE	SP and PDE
Younger group	r (19) =.97, p<.01	r (18)=.71, p<.01	r (10)=.65, p=.02	-	-
Older group	r (13)= .94, p<.01	r (13)=.49, p=.07	-	r (13)=.31, p=.26	r (13)= .20, p=.48
Combined group	r (34) =.97, p<.01	r (33) =.68, p<.01	r (10)=.65, p<.05	r (14) =.35, p=.19	r (14) =.29, p=.28

2.4.4 Experiment 2 Discussion

The aim of experiment 2 was to validate the Morphological Awareness dynamic task with Reception aged children (4-5-year-olds). Validation of the task for the target sample was carried out using a four-pronged approach: Intra-item reliability through item analysis, links to established measures, suitability for the intended age group, and dynamic contribution. The Morphological Awareness dynamic task was administered to children, along with established and standardised background measures namely vocabulary, phonological awareness, sight word reading and non-word reading. With regards to the differences found between derivational and inflectional items, it is worth noting that both derivational items were located within the less difficult half of items (second and sixth easiest of 18 items). Although there were only two derivational items, it is unexpected that both of these items were found to be easier for the participants given that researchers generally find that children develop inflectional morphological awareness before derivational morphological awareness (Carlisle, 2000).

The results have shown that this novel task is a valid and reliable measure of Morphological Awareness for Reception aged children. Morphological Awareness dynamic scores correlated positively, strongly, and significantly with vocabulary and phonological awareness for the target group of younger children (mean age 59.63 months) but not the older children or the combined groups.

2.5 General Discussion

Experiment 1 illustrated that it is feasible to use a dynamic morphological awareness task with younger children (i.e., under the age of six). The reliability and validity of the final dynamic morphological awareness task was illustrated in experiment 2. This version contained 18 sentence completion items, each of which were supported by up to six increasingly supportive and theory-driven prompts (prompt 1: explicit morphology, prompt 2: analogy, prompt 3: phonological awareness-addition, prompt 4: segmentation, addition, prompt 5: phonological awareness- segmentation, addition, blending, prompt 6: repetition).

2.5.1 Item Reliability through Item Analysis

In experiment 2, specific analysis of the task items evidenced its reliability and validity. Cronbach’s alpha was fairly high at $\alpha = .77$, further supporting experiment 1’s finding of high internal consistency. Deeper analysis into the usefulness of different prompts across each of the age groups was informative. In order to assess how participants were differentially deciphering items, the usefulness of prompts was examined according to item difficulty. The findings of these analyses in both experiments 1 and 2, suggest that participants use different strategies and thus find different prompts more useful dependent on how difficult each item is deemed. The items were ordered from least difficult to most difficult, according to participant mean score. Based on this, two groups were created: more difficult items and less difficult items. The first prompt, which requires the participant to engage with more explicit morphological awareness, was found to be more successful with the older than younger children. This suggests that older children are more able to use explicit morphological awareness than younger children. This developmental pattern is expected. Conversely, the younger children found the final prompt to be the most useful, since this prompt was a straightforward repetition of the answer, this perhaps indicates a lack of morphological awareness for those items.

Overall, the participants used prompt 2 the most for the more difficult items (i.e., those items which garnered lower scores), evidencing the need for further contextual information. Prompt 2 provided an analogy for the target by requiring the child to complete the sentence with a similar, more frequent morphologically complex word. The usefulness of this prompt for the more difficult items perhaps indicates active learning, understanding, and application of morphological rules from one more familiar sentence completion sentence to another more difficult one. Indeed, Ram et al. (2013) has shown that children are able to define more morphologically complex words in context than in isolation, highlighting the importance of context in morphological analysis.

2.5.2 Links to Literacy and Language

By administering the task to a wide age range of children (51-106 months) in experiment 2 and then splitting the participants into two groups according to age, I was able to ascertain whether the task was suitable for the intended younger age group. As expected, the older children did perform better than the younger children, and certainly several of them were performing at ceiling.

Across combined age groups, as expected, the MA task correlated moderately to strongly with both phonological awareness and vocabulary. Further analysis according to age revealed that the morphological awareness task did correlate strongly with standardised vocabulary and phonological awareness for the younger children but not for the older children. This would imply, firstly, that the task is particularly suited to the younger age group. Secondly, by analysing links to established background measures which have been shown to tap morphological awareness, task validity was established. This finding suggests that the task is valid for this age group as vocabulary (Kirby et al., 2008; McBride-Chang et al., 2005; Sparks & Deacon, 2015) and phonological awareness have been closely linked to morphological awareness in several previous studies. Finally, the increased performance from the younger group to the older group suggests developmental progression, which is also an important form of validity.

An important question is why the morphological awareness task correlates with vocabulary for the younger children but not for the older children. The strong correlation between vocabulary and the morphological awareness task in the younger children, points to a strong relationship between vocabulary and morphological awareness at this age. That is, those children that perform better at vocabulary tend to perform better at the morphological awareness task. Perhaps the younger children depend heavily on vocabulary as part of their strategy to decipher the correct morphologically complex word whereas the older children use some other strategy which does not rely as much on vocabulary. In line with this, Bowey and Patel (1988) found that language (measured by vocabulary and sentence imitation) added to the prediction of reading achievement in very young children. It is also possible that a relationship between the two variables does also exist with the older children, but it was not possible for a correlation to emerge due to the ceiling effects shown in the older participant's morphological awareness data. Due to the lack of sensitivity found for older children, future studies might develop more complex items to avoid celling effects in this age group (i.e., 6-8 years old). Nevertheless, for the current thesis, the aim was to develop a task that would be suitable for children at the earliest stage of education (i.e., 4-5 years old).

2.5.3 Dynamic Contributions

Finally, and crucially, it is worth noting that none of the literacy or language measures correlated with the static portion of the task for either of the age groups. This suggests then that the dynamic portion of the task lends further richness in information to the task over and above the static portion. This, in turn allows for insight that would otherwise be inaccessible. The dynamic data offers further variability in the data in the form of learning potential (i.e. through the prompts).

These findings are in line with past research that has found that the data gained from dynamic assessment provides important insight due to a wide range of skill levels and positive links to children's literacy levels (Larsen & Nippold, 2007; Wolter & Pike, 2015). For example, Larsen and Nippold (2007) tested 12-year-olds and found that their Dynamic Assessment Task of Morphological Analysis correlated with word reading and reading comprehension, although vocabulary was not tested. The current study has found that dynamic assessment is linked to vocabulary in much younger children. Perhaps, younger children rely on vocabulary whilst older children rely more on more literacy-based measures such as comprehension and word reading. However, as the phonological awareness and word reading measures did not show significant links in the present study, and vocabulary was not measured in Larsen and Nippold's study, it is difficult to directly compare. This study has shown, in any case, that dynamic assessment is a viable tool for investigating morphological awareness in much younger children (4-5 years old) than has been previously studied.

2.5.4 Limitations and future directions

Due to the data collection occurring at a children's event, the standardised literacy measures (PIPA, TOWRE and BPVS) were centrally collected for all researchers. There are some issues with the tests themselves. The PIPA contains very few morphologically complex words, and this may have attenuated the relationship found with the morphological awareness task. TOWRE, which is a timed test, may tap processing speed, thereby raising concerns over its validity for assessing real and non-word reading. Thus, in the following chapter, BAS3 word reading subtest was employed to test word reading.

A ceiling effect was observed for the older participants but not the younger participants. Since the study in the following chapter was aimed at Reception aged children (4-5-year-olds), the sample in experiment 2 of this chapter was split between younger (mean age=59.38) and older children (mean age=82.87). Although there was a negative skew for the younger children (-0.79), this was lower than the skewness value found for older children (-1.27). At time 2 of the main study in the following chapter 3, children were aged 5-6 years old. Based on the findings from the experiments in this chapter, it was decided that at time 2 of the main study, responses to prompt 1 would be recorded, regardless of whether a correct or incorrect response was given initially. Recall that in experiment 2, prompt 1 was not administered to children who correctly answered the initial target question (i.e., if the initial target question was correctly answered no prompt necessary was recorded). Prompt 1 examines their explicit knowledge of morphological rules. Given children would be older at time 2, a specific prompt 1 score may help to further separate children with implicit understanding of morphology to get to the correct answer, from children with higher-level abstract and explicit knowledge of morphology and its rules.

2.5.5 Conclusions

In experiment 1, the dynamic assessment of morphological awareness task was carefully developed using a concurrent assessment and development strategy. Feedback from piloting on child participants was used to provide on-going amendments to the task. The task was deemed to be suitable for three reasons: Cronbach's alpha score of .80 suggested good internal consistency and significant correlations with phonological awareness, letter-sound knowledge, vocabulary, real word reading, and non-word reading demonstrated validity.

In experiment 2, a four-pronged approach was used to determine reliability and validity: Intra-item reliability through item analysis, suitability for the intended age group, links to established measures, and dynamic contribution. As in experiment 1, intra-item reliability was established with a high Cronbach's alpha score of .77. In experiment 2, analyses were split by age group with the target age group (i.e., 4-5 years old) and an older age group (i.e., 6-8 years old). Importantly, significant and strong correlations were found between the dynamic assessment of morphological awareness and each of phonological awareness and vocabulary for the younger target group, but not the older age group. This provided evidence that the task was suitable for the younger age group. Also, ceiling effects were found for the older age group and not for the target younger age group suggesting developmental progression in the task. Finally, the dynamic portion of the task provided rich and varied data over and above the static portion. Thus, findings from Chapter 2 suggest that the dynamic assessment of morphological awareness is a reliable and valid task for examining morphological awareness in children at the earliest stage of education (i.e., 4-5 years old).

3 Morphological Awareness: From Oral Language to Literacy

3.1 Abstract

In the current chapter, the novel dynamic assessment of morphological awareness devised in chapter 2 was employed to examine morphological awareness in Reception aged children (4-5 years old). To assess how morphological awareness in oral language contributes to literacy development, literacy measures including spelling, word reading and reading comprehension were examined a year later. Importantly, a novel analogous phonological awareness task was created to control for the specific effects of phonological awareness in the dynamic assessment of morphological awareness. Findings revealed that morphological awareness at time 1 predicted significant variance in reading comprehension at time 2, even after conservatively controlling for phonological awareness using the novel analogous task. At time 2 concurrent links were found between morphological awareness and each of spelling, word reading and reading comprehension. As discussed in chapter 2, finding morphological awareness in this young age group has important theoretical and practical implications. In the case of theoretical implications, children at the earliest stage of education should have less exposure to formal education, thus minimising orthographic contributions to morphological awareness assessment. Therefore, we can be more certain that findings are due to a purer measure of morphological awareness and not inadvertent orthographic contributions. In the case of practical implications, finding that morphological awareness in early oral language contributes to literacy development might have important implications for its strengthened inclusion in the early primary years' curriculum.

3.2 Introduction

The aim of chapter two was to validate the dynamic assessment of morphological Awareness. Two experiments were carried out, one to develop the task, and the other to validate the design. Those studies supported the task's suitability for assessing the morphological awareness of 4-6-year-olds. A key following question was whether morphological awareness in oral language of beginner readers would contribute diachronically to literacy development. Here, following on from chapter 2, a study was carried out to examine how morphological awareness in emergent readers (4-5 years old) contributed to literacy, both concurrently, and longitudinally a year later.

Morphological awareness combines several levels of language processing including semantics, pragmatics, syntax, phonology, spelling, and vocabulary (Stemberger, 1995). Therefore, it is important to gain a better understanding of how these different language functions contribute to the explicit use of morphology in communication in young children. Using the validated Dynamic Assessment of Morphological Awareness task, the current chapter sought to elucidate links between morphological awareness in oral language and literacy development. For example, we are still uncertain whether morphological awareness emerges before formal instruction or is dependent upon literacy instruction (Carlisle & Feldman, 1995). Moreover, findings of morphological awareness effects on literacy development may often be attributed to orthographic and phonological effect. There are three potential reasons for this. Firstly, tasks measured in written language are susceptible to confounds with orthographic effects (Deacon et al., 2014). That is, it may be difficult to disentangle pure morphological awareness from orthographic effects in written tasks. Secondly, older children with significant exposure to written exposure may be more likely to apply phonological strategies to morphological awareness tasks (Cunningham & Carroll, 2015). Thus, assessing this skill in younger children may diminish these unintended effects.

Finally, it is precisely due to these unintended phonological effects that researchers have sought to control for phonological awareness (Deacon & Kirby, 2004). Thus thirdly, in order to control for the effects of phonological awareness, the skill must be tightly controlled in the experimental design. In the current chapter, these issues were all addressed by examining the contribution of morphological awareness in the oral language of beginner readers to literacy development a year later. Moreover, phonological awareness was carefully controlled by developing an analogous phonological awareness task which controlled for the specific phonological effects of the morphological awareness task.

3.2.1 Morphological Awareness: A Metalinguistic Skill

As in the previous chapters, morphological awareness is defined as children's conscious awareness of the minimal units of meaning and their ability to explicitly manipulate morphemes, employing word formation rules. Morphological awareness differs from other types of morphological knowledge and processes due to the role of metalinguistic awareness. Metalinguistic awareness is one's ability to reflect on and manipulate different elements of language (Nagy & Anderson, 1999). Metalinguistic skill is distinct in that it highlights the structure rather than the content of language. Fluent readers are able to use language implicitly, without attending to its structure. On the other hand, developing readers, such as young children and second language learners, must consider the linguistic elements used to convey the messages in writing (Tunmer & Bowey, 1984). Indeed, learning to read is a wholly metalinguistic endeavour, with children being explicitly taught the alphabetic principle, which involves phonemic awareness (Liberman et al., 1989). For example, when children learn the letter *b*, they must consider, explicitly, that *b* as a grapheme is linked to a corresponding phoneme. Thus, metalinguistic awareness is an important skill in word reading.

Further, metalinguistic awareness itself encompasses various aspects of language (e.g., morphemic and phonemic awareness). It has been established that very young readers (e.g. during the primary years) are able to attend to the phonemic features of language (Gray & McCutchen, 2006; Høien et al., 1995; Kirby et al., 2003). And although several studies have provided strong evidence that morphological awareness contributes to literacy development in older children, the evidence for younger children is still lacking (Deacon & Kirby, 2004). It may be argued that the language units in phonemic awareness are smaller and thus easier to process than those in morphemic awareness. Or perhaps, morphological awareness may develop later due to its complexity. Phoneme awareness is restricted to a phoneme embedded in a word and is largely unaffected by surrounding syntax and grammar. Morphological awareness, on the other hand, requires the learner to access the grammatical, syntactical and semantic features of a sentence. For example, for a child to pluralise a given word (e.g., *apple*), they must understand that -*s* is added to *apple* when there are more than one.

It is indeed this multidimensionality that causes morphological awareness to be critical for literacy development (Levesque et al., 2020). English is a highly multimorphemic language, drawing attention to the importance of morphological knowledge. Roughly 80% oral and written English words contain multiple morphemes (Anglin et al., 1993; Hiebert et al., 2018). Further, the majority of unfamiliar words encountered by children are morphologically complex (Nagy & Anderson, 1984; White et al., 1989). Carlisle and Feldman (1995) argued that as a metalinguistic skill which taps several other skills including phonemic, semantic and syntactic awareness, morphological awareness may be a more comprehensive index for literacy development than such skills alone. This premise has been supported by a wealth of studies investigating the relationship between morphological awareness and various literacy skills (Apel et al., 2013; Kirby et al., 2008; Singson et al., 2000; Wolter et al., 2020).

3.2.2 Morphological Awareness and Literacy Development

Initial research into the contribution of morphological awareness has found robust evidence for concurrent links between morphological awareness and various literacy skills (Levesque et al., 2020). Nevertheless, one possibility is that these contributions are underpinned by origins in phonological awareness or some other global literacy skill (Deacon & Kirby, 2004). This line of reasoning contends that morphological awareness is not an independent separable skill, but dependent on the awareness of smaller units of phonemes. However, recent studies have included skills such as phonological awareness and intelligence (Apel & Thomas-Tate, 2009; Deacon & Kirby, 2004; Kirby et al., 2008). If the contributions of these variables are controlled, yet effects are still observed for morphological awareness, we can reasonably assume that any variance attributed to morphological awareness is genuine.

Another point to note is that much of the literature investigating the relationship between morphological awareness and literacy measures have revealed a two-way street (Levin et al., 1999). Children may use morphological awareness as a literacy tool, yet morphological awareness is itself further developed through reading and exposure to literacy. In order to untangle the contribution of morphological awareness to literacy skills, longitudinal analysis has been invaluable (Kirby et al., 2012). Longitudinal studies reveal patterns in development between various literacy measures. Moreover, it is reasonable to suggest that assessing morphological awareness in the oral language of beginner readers with limited exposure to reading and writing would provide even further clarification on its contribution to literacy development. In the following paragraphs, I will discuss past research on the relationships between morphological awareness and word reading, spelling and reading comprehension.

Word reading has been linked to morphological awareness, above and beyond the effects of phonological awareness. For example, Kirby et al., (2012) found that morphological awareness was a significant predictor of word reading accuracy and speed, and pseudoword reading accuracy after controlling the effects of verbal and nonverbal ability and phonological awareness. Having knowledge of the impact of morphological boundaries in words should help in word decoding. For example, awareness of the prefix *un* in *uninformed* might aid in its distinction from *un* in *university*. This skill, called morphological decoding, is evidenced by studies which show that children use morphemes in word reading. For example, Carlisle and Stone (2005) found that children read words with two morphemes more accurately than words with one morpheme. One of the main reasons for this is the 'added value' provided by morphemic units, above and beyond other units like phonemes. Morphemes contain semantic, orthographic and phonological information which allow for quicker lexical representation as well highlighting the relationship between form and meaning. Highlighting this in practical terms, Apel et al., (2013) found that children's ability to infer meaning relations between different words which share common morphemes was linked to word reading. Children's reliance on morphemic units is a separable pathway through central orthographic processes to lexical representations (Levesque et al., 2020).

Turning to spelling, few studies have examined the diachronic relationship between morphological awareness and spelling in young children (e.g., below 7-years old). Instead, most studies have examined morphological decoding during the process of spelling (Levesque et al., 2020). These studies have found that skilled spellers use morphological structure to spell morphologically complex words (Kemp, 2006; Treiman & Cassar, 1996). For example, 5-8-year-olds spell inflected words more accurately than controls with the same consonant ending (Deacon & Bryant, 2005) whilst 9-year-olds show the same pattern with derivations (Sangster & Deacon, 2011). Much of the same mechanisms using sensitivity to morphological structure which underpin morphological decoding in reading might hold true in spelling. For example, as discussed previously, children read words with two morphemes more accurately than single morpheme words (Carlisle & Stone, 2005). Similarly, children use their knowledge of base forms to spell inflected and derived words more accurately than single morpheme words (Kemp, 2006).

Yet these findings do not necessarily tell us whether morphological awareness, more generally, contributes to spelling outcomes. Spelling outcome studies measure morphological awareness and spelling separately in an effort to establish a relationship (or lack thereof). There is evidence that morphological awareness predicts unique variance in spelling, even after controlling for other skills (Apel & Lawrence, 2011). Strikingly, Apel et al., (2012) found that morphological awareness, and not phonemic or orthographic awareness, was the only metalinguistic skill to contribute unique significant variance to spelling. The authors noted that inconsistent findings for morphological awareness contributions to spelling across studies may be due to differences in task. Of note, their task employed real words, both derived and inflected. Using real words may tap morphological spelling strategies, whilst non-words might tap phonemic strategies.

Deacon et al., (2009) went a step further by examining the longitudinal contribution of oral morphological awareness to spelling outcomes. Morphological awareness was assessed in seven-year-olds and spelling outcomes were measured two years later. Morphological awareness in oral language contributed to spelling outcomes after controlling for verbal and non-verbal intelligence, rapid automised naming, verbal short-term memory and phonological awareness. This study cements the importance of oral morphological awareness for subsequent spelling outcomes. Oral morphological awareness of young children should be impervious to the effects of orthographic knowledge inherent in reading ability.

Most recently, Enderby et al., (2021) found that morphological awareness predicted multisyllabic spelling in 7-10-year-olds. They argued that, crucially, studies which have not found a prominent role for morphological awareness largely examined shorter one to three syllable words. However, the age at which morphological awareness begins to contribute to spelling performance is still unclear. For example, does morphological awareness begin to contribute to spelling before or after exposure to reading and writing? The study in the current chapter answered this question by examining the contribution of morphological awareness to spelling in beginner readers.

Finally, a wealth of studies has highlighted the role of morphological awareness in reading comprehension (Carlisle, 2000; Deacon & Kirby, 2004; Deacon et al., 2014; Kieffer & Lesaux, 2012; Tong et al., 2011). Morphological awareness reflects a metalinguistic understanding of syntax and semantics which supports the development of reading comprehension (Goodwin et al., 2017). Indeed, there are strong reasons to acknowledge the importance of morphological awareness in the development of reading comprehension. Firstly, as discussed above, the majority of unfamiliar words encountered by children in written text are morphologically complex (Anglin et al., 1993). It follows then, that if children are able to use morphological knowledge at the word-level to decipher these words, they will be more likely to unlock meaning at the text-level. Secondly, morphological awareness, which encompasses text-level skills such as grammar and syntax should directly facilitate reading comprehension. Accordingly, several researchers argue that morphological awareness impacts reading both directly through the language system and indirectly through word reading skills (Deacon et al., 2014; Levesque et al., 2020; Perfetti et al., 2005).

Levesque et al. (2019) investigated morphological awareness across Grade 3 (8-9-year-olds) and Grade 4 (9-10-year-olds) employing a similar sentence completion paradigm as was used in the present study. They found that although morphological awareness did not contribute to later reading comprehension, it supported the development of reading comprehension through decoding of morphologically complex words. Thus, word decoding strategies played a moderating role in the relationship between morphological awareness and reading comprehension in 8-10-year-olds.

Similarly, James et al., (2021) found that whilst morphological awareness predicted significant variance in reading comprehension for younger (6-8 years old) and older children (12-13 years old), it did not for the middle age group (9-11 years old). Moreover, for the younger group, the contribution was found to be the strongest. However, the oldest age group performed the morphological awareness tasks using written format, while the two younger age groups performed the tasks in both written format and orally. Thus, the weaker findings for this age group may be due to inadvertent orthographic effects which would be subsumed by the background measures. In other words, the written morphological awareness tasks and the background measures may have been sharing variance for the same orthography related skills, without tapping new variance from morphologically related skills. In any case, it is noteworthy that both of the studies discussed above failed to find direct contributions of morphological awareness to reading comprehension in the later primary years (9-11 years old) but that the latter study did for younger children.

Importantly, the current study investigated morphological awareness in the oral language of 4-5-year-old emergent readers. By testing children with immature reading ability, it is expected that morphological awareness in oral language should be a purer measure without influences of orthographic input. In line with previous research, it was expected that morphological awareness at time 1 would contribute to time 2 (a year later) reading comprehension (Deacon & Kirby, 2004; Katz, 2004; Levesque et al., 2017), word reading (Kirby et al., 2012) and spelling (Deacon et al., 2009). In particular, it was expected that morphological awareness would contribute the most to reading comprehension as the literature has been most consistent on the strength of this relationship (Cunningham & Carroll, 2015; Deacon & Kirby, 2004; James et al., 2021).

3.2.3 Current Study

The current study elucidated the origins of the contribution of morphological awareness to reading by assessing morphological awareness in young (4-5-year old) children with minimal reading skills. Oral morphological awareness of such young children should be more impervious to the effects of orthographic knowledge inherent in reading ability. I argue that in order to truly understand how morphological awareness supports literacy development, assessment of morphological awareness at a younger age would be insightful. Thus, a key contribution of the current study is in the age, and consequent immaturity of orthographic knowledge of the children being examined. In the paragraph below, I explain why this is important.

In many aspects, morphemic relationships within words are more consistent and transparent in written than oral language (Rastle, 2018). For example, the past tense suffix '-ed' is consistently spelled to preserve its morphological structure despite differences in pronunciation. The words *slipped* and *lasted* both contain the past tense suffix '-ed', despite phoneme-spelling inconsistencies (i.e., *slipped* pronounced /slɪpt/ and *lasted* pronounced /lɑːstɪd/). If younger emergent readers can be shown to possess morphological awareness, this may suggest a purer understanding of morphological relationships unaided my orthographic knowledge. Yet, several studies have found evidence to suggest that morphological awareness is more beneficial to intermediate and older readers, and not beginner readers (e.g.

Berninger et al., 2010). However, this weaker relationship may be due primarily to the difficulty of assessing such an abstract language skill in cognitively undeveloped learners.

Moreover, studies have shown that even pre-school children with little to no literacy instruction benefit from training in morphological awareness. For example, Lyster et al., (2016) carried out morphological awareness training, phonological awareness training or no training to three groups of Norwegian-speaking pre-schoolers with no formal literacy instruction. Whilst both experimental groups were found to exceed the control group in reading comprehension a year later, only the morphological awareness group maintained these improvements 5 years later. Thus, there are clearly important practical implications for examining whether morphological awareness in early oral language contributes to literacy development in English.

In order to assess such young children, the dynamic task validated in the previous chapter was employed in the current chapter. The dynamic assessment task is ideal for several reasons. Firstly, the very young children involved in this study should be aided by scaffolding in the prompts, avoiding floor effects. Secondly, the prompts were created to highlight the theoretical underpinnings of morphological awareness. Thus, it was possible to analyse which skills contribute to morphological understanding. Moreover, we can explore whether certain children have higher levels of metalinguistic knowledge through the first prompt. This prompt asked children to consider the morphological rule, thinking more abstractly about the structure, and not the content of language. It was expected that the ability to correctly answer prompt one would highlight children with even deeper, metalinguistic awareness of morphology. This would be reflected by a strong relationship between prompt one scores and the literacy measures.

Regarding, morphological awareness and its contribution to literacy development, it was hypothesised that the dynamic assessment of morphological awareness would contribute unique variance a year later in word reading, spelling and reading comprehension, as highlighted for older children in the literature. It is worth noting that my design was particularly conservative, having controlled for phonological awareness with a novel task which tapped the specific phonological contribution of the dynamic assessment of morphological awareness.

To conclude, the current study elucidated the role of morphological awareness in literacy development by assessing morphological awareness in the oral language of emergent readers. Word reading and reading comprehension and spelling were measured a year later to determine how morphological awareness in language contributes to the development of literacy.

3.3 Methodology

3.3.1 Participants

Table 13 shows the number, age and sex of participants at time 1, and time 2. Also shown is participant information at time 1 for those children who weren't affected by attrition at time 2.

Table 13.

Longitudinal Study Time 1 and Time 2 Participant Information

	Time 1 (all children)	Time 1 (children with t2 data)	Time 2
N	43	40	40
Age in months	62.44 (3.38)	62.43 (3.49)	74.43 (3.46)
Sex			
Male	22	21	21
Female	21	19	19

Fifty-two children were recruited at time 1 from three schools in the Midlands region of England, United Kingdom. Of these, nine participants' data have been removed from all analyses due to developmental disorders (N=5) and parent withdrawal at time 2 (N=4). Of the remaining forty-three participants, three participants' data were unavailable at time 2 due to changing schools before time 2 data collection. There was viable data from 43 participants at time 1 for the concurrent analyses and 40 participants at time 2 for the longitudinal analyses.

Ethical approval was gained from the Health and Life Sciences Research Ethics Committee at Coventry University prior to recruitment and data collection. Written consent for data collection at times 1 and 2 were obtained from parents at time 1. At time 2, before data collection started, parents were reminded about the study and asked if they were still happy for their child to take part at time 2. Children provided oral assent and were reminded of their right to withdraw in child-appropriate language.

3.3.2 Procedure

Tests were administered individually to participants in a quiet area within their school. Children were tested on three separate sessions at each time point for the following skills: 1) dynamic assessment of morphological awareness 2) analogous phonological awareness 3) background measures (non-verbal skills, letter-sound knowledge, vocabulary, sound deletion, and sound isolation) 4) literacy outcome measures (word reading, reading comprehension, and spelling).

Standardised tasks were administered and scored as per their manuals. For these assessments, standardised scores were used for all analyses. Time 1 measures were administered in the spring/summer terms of Reception in 2018. Time 2 measures were administered in the spring/summer terms of Year 1 in 2019.

3.3.3 Measures

3.3.3.1 Tasks Administered at Time 1 only

Note that British Ability Scales **(**BAS) Matrices and YARC letter-sound knowledge were administered at time 1 only.

British Ability Scales Matrices (BAS) 3. The BAS Matrices were administered to assess participants non-verbal skills (Elliott et al., 1997). Specifically, it measures the child's ability to recognise relationships between shapes, determine and use rules, and use problem-solving skills.

Letter-Sound Knowledge. The letter-sound knowledge core test from the YARC was administered to assess the development of pre-reading skills in children (YARC; Snowling et al., 2009) . Children were asked to provide the corresponding sounds for the letters of the alphabet as well as for three vowel digraphs and three consonant digraphs.

3.3.3.2 Tasks Administered at Time 2 only

Spelling and Reading comprehension were administered at time 2 only.

Spelling. The spelling task used was taken from Breadmore and Deacon (2019) which was originally adapted from Deacon and Dhooge (2010). There were three sets of seven words (21 words in total). Each set of seven words were either the base form (e.g., *rock*), the base form embedded within a control word (e.g., *rocket)* or the base form embedded within a morphologically complex word (e.g., *rocking*). Participants heard the target word, followed by the word within a sentence, and finally the word again. Eye and Pen 3 was used to run the experiment. Words were written down using an inking pen on a piece of paper overlaid on the tablet. Accuracy totals for spelling across all the administered words. Unlike Breadmore and Deacon (2019), timing data was not examined because low accuracy precluded this analysis, which is only conducted on correct spellings.

Reading Comprehension. The York Assessment of Reading for Comprehension: Early Reading and Passage Reading Primary was used to assess participants' reading comprehension (Martin, 2011). Children were timed and accuracy-scored on their reading of a passage. They then answered a series of reading comprehension questions about the passage.

3.3.3.3 Tasks Administered at Times 1 and 2

Dynamic morphological awareness, analogous phonological awareness, vocabulary, word reading, sound isolation and sound deletion were administered at times 1 and 2.

Dynamic Morphological Awareness. The dynamic morphological awareness task was administered as described in chapter 2. Forty children attempted this task at time one (spring/summer of Reception). However, of these, 22 children could not fully complete this task. The task appeared to require substantial focus for the 4-5-year-olds, therefore it was stopped prematurely for a sub-group of children who demonstrated distress/ loss of attention during testing. Out of 40, thirty-eight children completed at least the first 11 items and 18 participants completed all 18 items. Thus, analyses were split into two groups. The first group (18 items) consisted of the children who completed all 18 items at time 1 and analyses were carried out on the full battery for these 18 children only. The second group (11 items) consisted of the larger set of 38 participants who completed at least the first 11 of the items at time 1. Analyses were carried out on the first 11 items only. This was not an issue at time two, where all 40 children completed all items. Internal consistency across the items was good. Cronbach's alpha for the items across participants who completed all the items at time 1 was 0.76. Cronbach's alpha for the items across participants who completed at least the first 11 items was 0.88.

Scoring the dynamic morphological awareness task for metalinguistic awareness. In order to gain access to a deeper, metalinguistic knowledge of morphology, prompt 1 was devised and used in the final task in experiment 2 of chapter 2, asking children about their knowledge of the morphological rule for each item (see flowchart for prompts of the final task on page 82 of Chapter 2). For example, consider the item 'This is my nose. These are their (noses)'. Prompt 1 for this item was 'When there is more than one of something, we add something to the end of the word. What do we add?' This served to test children on their understanding of the structure of language as opposed to its contents. At time 1, children's answers to prompt one were not recorded. Instead, only the number of prompts necessary to gain the correct answer for each item was recorded (as in the validated task described in Chapter 2). At time 2, all children's answers to prompt 1 were recorded, whether or not they then went on to answer the target question correctly. This was done because children at time 2 were expected to possess an increased ability to think more abstractly about their language use. In addition, asking this prompt to all children would provide further insight into those children with higher metalinguistic abilities, and provide further variability in the data. Further, consideration was given to the types of answers children gave to prompt 1. Take the prompt 1 example given above. If the child answered phonologically 'iz', this was noted as a phonological credit. If the child answered orthographically 's', this was noted as an orthographic credit. An answer which reflects orthographic links may even further demonstrate abstract understanding of morphological structure. Thus, for the prompt 1, three variables were generated: Orthographic score, phonological score and prompt 1 score (total proportion of correct answers to prompt 1). For clarity, Table 14 below shows how the task evolved across chapters 2 and 3.

Table 14.

Table Showing the Changes in how the Task was Administered During the Development, Validation and Longitudinal Studies.

Location	Experiment	Number of prompts	Change from previous task administered
Chapter 2, experiment 1	Task development	5	Not applicable
Chapter 2, experiment 2	Task validation	6	For experiment 2 of chapter 2, prompt 1 was added and used in the same manner as the other prompts. It tested knowledge of morphological rules.
Chapter 3, time 1	Longitudinal time 1	6	None
Chapter 3, time 2	Longitudinal time 2	6	At time 2, the layout of the prompts remained unchanged. All participants were asked prompt 1, irrespective of if they answered the initial target question correctly. Additional scores were recorded for prompt 1 as discussed in the section above.

Analogous Phonological Awareness (PA analogous). A novel phonological awareness task was created to control for any effects of phonology in the dynamic morphological awareness task (see Appendix C for a list of these items). This task was designed to control specifically for knowledge of the phonemes in the morphological awareness task. This was done by selecting similar phonemes to those phonemes in the target morphologically complex words of the morphological awareness task. This process resulted in the creation of novel words which were phonologically analogous to the target words of the morphological awareness task. Similar phonemes were determined using Singh and Woods (1971) global similarity ratings. Each item contained two parts: the nonword root and affix, with similar phonemes to the root and affix, respectively, of the corresponding morphologically complex target word. For example, the target multimorphemic word 'noses' contains the phonemes 'n əʊ z' in the root (nose) and 'ɪ z' in the affix (es). Using the global similarity ratings, the phonologically analogous word 'məʊzəs' (mosase) was created with the nonword root 'məʊz' (mos), and the nonword affix 'əs' (ase).

For this task, the children were given the root and affix separately and asked to blend these together. Each correct answer was given a score of 1. The number of correct answers were summed for a final total score for each participant.

Vocabulary. Receptive vocabulary was tested using the British Picture Vocabulary Scale: Third Edition (BPVS3) (Dunn & Dunn, 2009). For each item, the investigator said a word which corresponded with one of four pictures. The child was required to point to the picture which best represented the spoken word. The published reliability has been reported as 0.91.

British Ability Scales (BAS) 3 Word Reading. The ability to read printed words was tested using the word reading subset of BAS 3 (Elliott et al., 1997). Children read aloud a series of printed words and were scored on the number of correctly read words. Reading was stopped when children read two or fewer correct words in a block of ten.

York Assessment of Reading for Comprehension: Sound Deletion and Sound Isolation. Participants were tested on their phonological awareness using two subtests from the York Assessment of Reading for Comprehension (YARC; Snowling et al., 2009). Firstly, the sound isolation task tested phoneme awareness and required participants to identify and produce the initial or final phonemes of twelve monosyllabic non-words. Secondly, the sound deletion task required participants to delete a syllable or phoneme from real words, presented with corresponding pictures. For two items, children were asked to delete the first or last syllable from bisyllabic words. For the remaining monosyllabic items, children were asked to delete the initial, medial or final phoneme.

3.4 Results

Responses to a battery of tasks measuring dynamic morphological awareness, phonological awareness and literacy and language skills at times 1 and 2 were recorded. The means, standard deviations and ranges for each measure at each time point are shown in Table 15. Participants appeared to be typically developing with high phonological awareness and letter-sound knowledge, possibly as a result of their phonics instruction. Standardised scores were used for all measures except dynamic assessment of morphological awareness, analogous phonological awareness and the spelling task. The maximum possible score for morphological awareness (first 11) was 66. The maximum possible score for morphological awareness (all 18) was 108. All variables conformed to the assumptions of regression (independent errors, no multicollinearity, normally distributed errors, homoscedasity, and linearity).

Table 15.

Means, Ranges and Standard Deviations for Performance on Measures at Times 1 and 2

Variables	N	Minimum	Maximum	Mean	Std. Deviation
			Time 1		
MA (first 11)	38	0	66	52.26	14.90
MA (all 18)	15	81	108	98.13	9.47
PA analogous (first 11)	38	0	11	7.58	2.85
PA analogous (all 18)	15	9	17	13.33	2.64
Word reading standardised score	38	78	130	100.92	12.02
Word reading raw score	38	0	49	10.29	12.19
BPVS standardised score	38	79	118	100.34	10.81
BPVS raw score	38	41	103	74.66	13.73
Letter-sound knowledge standardised score	38	86	130	119.79[a]	9.12
Letter-sound knowledge raw score	38	11	17	15.76	1.64
YARC PA composite standardised score	38	79	130	112.79[a]	13.00
YARC PA composite raw score	38	1	11.50	7.36	2.57
BAS Matrices	38	0	11	5.68	2.85
			Time 2		
MA (all 18)	38	61	108	102.37	8.89
PA analogous (all 18)	37	7	17	14.41	2.58
Word reading standardised score	38	84	128	107.87	11.87

Variables	N	Minimum	Maximum	Mean	Std. Deviation
Word reading raw score	38	2	71	38.66	21.37
BPVS standardised score	38	79	119	94.43	8.94
BPVS raw score	38	66	118	86.61	11.64
YARC PA composite standardised score	38	78	130	109.97	13.06
YARC PA composite raw score	38	3	12	9.69	2.2
Reading comprehension standardised score	38	81	122	105.08	12.80
Reading comprehension raw score	38	7	59	40	14.08
Spelling accuracy	38	0	19	8.94	5.22

[a] For PA composite, seventeen cases were at least one standard deviation above the mean (>115). For letter-sound knowledge, 29 cases were at least one standard deviation above the mean (>115). This may be due to the norming dates for the YARC PA and letter-sound knowledge.

Before conducting linear regression analyses, Pearson's correlations were calculated to elucidate the relationships between the variables at time 1 and time 2. Table 16 shows the associations between the variables using the morphological awareness (first 11) measure at time 1. Morphological awareness at time 1 was moderately and significantly correlated with the following time 2 measures: Vocabulary, r=.43, p=.008, analogous phonological awareness, $r=.43$, $p=.008$, YARC PA composite, $r=.46$ $p=.004$, reading comprehension, $r=.58$, $p<.001$ word reading, $r=.42$, $p=.009$ and spelling, $r=.37$, $p=.02$. Finally, morphological awareness at times 1 and 2 were moderately correlated, $r=.49$, $p=.002$.

Table 16.

Correlations Among MA (first 11) and PA (first 11) at Time 1 and Literacy/Language Measures at Times 1 and 2 (N=38)

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Time1														
1. MA (first 11)	-	.43*	.34*	.50*	*.18*	.44*	*.19*	.49*	.43*	.42*	.43*	.46*	.58*	.37*
2. PA analogous (first 11)		-	.60*	*.23*	.46*	.49*	.46*	.55*	.67	.58*	*.21*	.62	.67*	.53*
3. Word reading			-	*.25*	.36*	.42*	.33*	.48*	.48	.55*	*.15*	.46	.56*	.59*
4. BPVS vocabulary				-	.38*	*.25*	*.22*	*.22*	*.30*	*.28*	.57*	*.31*	.48*	*.08*
5. Letter-sound knowledge					-	.52*	*.13*	*.12*	*.21*	.35*	-*.12*	*.18*	.34*	*.14*
6. YARC PA composite						-	*.19*	*.12*	*.26*	.45*	*.06*	.63*	.48*	.35*
7. BAS matrices							-	.35*	.38	*.26*	.35*	*.25*	.44*	.28*
Time 2														
8. MA (all 18)								-	.70*	.44*	.36*	.43*	.42*	.41*
9. PA analogous (all 18)									-	.67*	.44*	.66*	.76*	.57*
10. Word reading										-	.34*	.70*	.77*	.76*
11. BPVS vocabulary											-	.36*	.53*	*.29*
12. YARC PA composite												-	.71*	.61*
13. Reading comprehension													-	.63*
14. Spelling accuracy														

Note. Correlations are Bivariate (Pearson's r). All correlations significant at p < .05 marked by an asterix (*).All correlations significant at p < .01 marked by two asterixes (**). Non-significant correlations are in italics.

Turning to Table 17, this shows the associations between scores for those participants that completed all 18 morphological awareness items and the literacy/language measures at time 1 and time 2. Morphological awareness (full 18) at time 1 was moderately and significantly correlated with just one time 2 task- reading comprehension, $r=.52$, $p=.05$. Other correlations might not have reached significance due to the considerably smaller sample size of the morphological awareness (all 18) data.

Table 17.

Correlations Among MA (all 18) and PA (all 18) at Time 1 and Literacy/Language Measures at Times 1 and 2

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14
					Time 1									
1. MA (all 18)	-	*.15*	*.33*	.51*	.52*	.56*	*.09*	*-.05*	*.24*	*.39*	*.35*	*.47*	.52*	*.40*
2. PA analogous (all 18)		-	.70*	*.41*	*.25*	*.44*	.58*	*.18*	*.34*	*.43*	.52*	.60*	.69*	.62*
3. Word reading			-	*.39*	*.26*	*.22*	*.43*	.54*	*.47*	*.40*	*.33*	*.45*	.61*	.66*
4. BPVS vocabulary				-	*.47*	*.43*	*.34*	*-.14*	*.11*	*.33*	.60*	*.46*	.72*	*.02*
5. Letter-sound knowledge					-	*.49*	*.04*	*-.43*	*.20*	.60*	*.07*	*.39*	.70*	*.22*
6. YARC PA composite						-	*.16*	*-.42*	*-.01*	*.21*	*.23*	.80*	.56*	*.15*
7. BAS matrices							-	*.37*	*.34*	*.08*	.70*	*.17*	*.35*	*.30*
					Time 2									
8. MA (all 18)								-	*.21*	*-.14*	*.31*	*-.25*	*-.17*	*.36*
9. PA analogous (all 18)									-	*.42*	*.19*	*.42*	*.50*	*.44*
10. Word reading										-	*.21*	*.44*	.74*	.67*
11. BPVS vocabulary											-	*.33*	*.44*	*.25*
12. YARC PA composite												-	.76*	*.35*
13. Reading comprehension													-	.51*
14. Spelling accuracy														

Note. Correlations are Bivariate (Pearson's r). All correlations significant at p < .05 marked by an asterix (*). Non-significant correlations are in italics.

Multiple linear regressions were carried out using SPSS. For all regressions, PA analogous and word reading were included to partial out their effects. Specifically, PA analogous was included as it was specifically created to be phonologically analogous to the target items in the morphological awareness task. In this way, including this measure would control for the effects of phonological awareness. Word reading was included in order to control for orthographic input. The first set of regressions, shown in Table 18, depict regressions of PA analogous (first 11), morphological awareness (first 11) and word reading predicting reading comprehension, word reading and spelling at time 2. For these regressions, the scores from participants that completed the first 11 items of morphological awareness and PA were utilized. For all regressions, a block-wise selection was applied, with PA analogous and word reading entered in step one and morphological awareness entered in step 2. For each of reading comprehension, word reading and spelling, morphological awareness contributed 10%, 3% and 1% unique variance respectively, beyond the effects of PA analogous and word reading. Only the contribution to reading comprehension reached significance. The total variances found after entering both steps for reading comprehension, word reading, and spelling were .58, .43 and .41, respectively.

Table 18.

Regressions Predicting Reading Comprehension, Word Reading and Spelling at Time 2 Using MA (first 11), PA analogous (first 11) and Word Reading as the Predictors

	Dependent variable at time 2														
	Reading Comprehension					Word Reading					Spelling				
Variable at time 1	B	SE B	β	P	R2	B	SE B	β	P	R2	B	SE B	β	P	R2
Step 1															
PA analogous (first 11)	2.33	0.68	0.52	.001	.48	1.66	0.68	0.40	.02	.40	0.51	0.30	.28	.10	.40
Word reading	0.27	0.16	.25	.11		0.31	0.16	0. 31	.07		0.18	0.07	0.42	.01	
Step 2															
MA (first 11)	0.29	0.11	0.34	.01	.58	0.14	0.12	0.18	.22	.43	0.05	0.05	0.13	.37	.41
PA analogous (first 11)	1.81	0.65	0.40	.01		1.40	0.70	0.34	.06		0.43	0.31	.023	.18	
Word reading	0.22	0.15	0.21	.15		0.28	0.16	0. 29	.09		0.18	0.07	0.41	.02	

The second set of regressions, shown in Table 19, depict regressions of PA analogous (all 18), morphological awareness (all 18) and word reading predicting reading comprehension, word reading and spelling at time 2. For these regressions, the scores from participants that completed all of the 18 items of morphological awareness and PA were utilized. For all regressions, a block-wise selection was applied, with PA analogous and word reading entered in step one and morphological awareness entered in step 2. For each of reading comprehension, word reading and spelling, morphological awareness contributed 15%, 6% and 1% unique variance respectively, beyond the effects of PA analogous and word reading. Again, only the contribution to reading comprehension reached significance. The total variances found after entering both steps for reading comprehension, word reading, and

spelling were .66, .21 and .37, respectively.

Table 19.

Regressions Predicting Reading Comprehension, Word Reading and Spelling at Time 2 Using MA, PA analogous and Word Reading as the Predictors

	Dependent variable at time 2														
	Reading Comprehension					Word Reading					Spelling				
Variable at time 1	B	SE B	β	P	R2	B	SE B	β	P	R2	B	SE B	β	P	R2
							Step 1								
PA analogous	2.44	1.04	0.62	.04	.51	1.46	1.49	0.34	.34	.15	0.62	.56	.33	.29	.36
Word reading	0.13	0.25	0.14	.61		0.07	0.36	0.07	.85		0.15	0.14	0.33	.30	
							Step 2								
MA	.41	.18	.43	.04	.66	.28	.30	.27	.37	.21	.04	.12	.09	.72	.37
PA analogous	2.22	.91	.56	.03		1.31	1.5	.31	.40		.59	.58	.32	.33	
Word reading	-.01	.23	-.01	.10		-.03	.37	-.03	.95		.13	.15	.30	.38	

The third set of regressions, shown in Table 20, depict regressions of PA analogous (first 11), morphological awareness (first 11) and vocabulary predicting reading comprehension, word reading and spelling at time 2. For these regressions, the scores from participants that completed the first 11 items of morphological awareness and PA were utilized. For all regressions, a block-wise selection was applied, with PA analogous and vocabulary entered in step one and morphological awareness entered in step 2. For each of reading comprehension, word reading and spelling, morphological awareness contributed 3%, <1% and 4% unique variance respectively, beyond the effects of PA analogous and vocabulary. However, none of these reached the level of significance. The total variances found after entering both steps for reading comprehension, word reading, and spelling were .59, .33 and .33, respectively.

Table 20.

Regressions Predicting Reading Comprehension, Word Reading and Spelling at Time 2 Using MA (first 11), PA analogous (first 11) and Vocabulary as the Predictors

	Dependent variable at time 2														
	Reading Comprehension					Word reading					Spelling				
Variable at time 1	B	SE B	β	P	R2	B	SE B	β	P	R2	B	SE B	β	P	R2
							Step 1								
PA analogous (first 11)	2.64	0.52	0.59	.000	.56	1.59	0.44	052	.001	.33	1.00	0.27	.54	.001	.29
Vocabulary	0.40	0.14	.34	.006		0.15	0.16	0.13	.366		-0.03	0.07	-0.05	.72	
							Step 2								
MA (first 11)	0.20	0.12	0.24	.089	.59	0.03	0.07	0.06	.732	.33	0.09	0.06	0.25	.16	.33
PA analogous (first 11)	2.29	0.54	0.51	.000		1.55	0.47	0.50	.002		0.85	0.29	.46	.005	
Vocabulary	0.28	0.15	0.24	.068		0.11	0.19	0.10	.558		-0.08	0.08	-0.16	.332	

The fourth set of regressions, shown in Table 21, depict regressions of PA analogous (all 18), morphological awareness (all 18) and vocabulary predicting reading comprehension, word reading and spelling at time 2. For these regressions, the scores from participants that completed all of the 18 items of morphological awareness and PA were utilized. For all regressions, a block-wise selection was applied, with PA analogous and vocabulary entered in step one and morphological awareness entered in step 2. For each of reading comprehension, word reading and spelling, morphological awareness contributed 3%, 7% and 21% unique variance respectively, beyond the effects of PA analogous and vocabulary. Perhaps surprisingly, only the contribution to spelling reached significance. The total variances found after entering both steps for reading comprehension, word reading, and spelling were .63, .21 and .62, respectively.

Table 21.

Regressions Predicting Reading Comprehension, Word Reading and Spelling at Time 2 Using MA, PA analogous and Vocabulary as the Predictors

	Dependent variable at time 2														
	Reading Comprehension					Word reading					Spelling				
Variable at time 1	B	SE B	β	P	R2	B	SE B	β	P	R2	B	SE B	β	P	R2
							Step 1								
PA analogous	1.97	0.79	0.48	.027	.60	1.51	1.26	0.34	.253	.14	1.36	0.45	0.71	.010	.41
Vocabulary	0.45	0.20	0.44	.040		0.07	0.32	0.06	.826		-0.18	0.11	-0.36	.147	
							Step 2								
MA	0.21	0.21	.21	.327	.63	0.34	0.33	0.30	.328	.21	0.25	0.10	0.52	.026	.62
PA analogous	2.10	0.80	0.51	.022		1.72	1.28	0.39	.202		1.52	0.39	0.79	.002	
Vocabulary	0.34	0.23	0.33	.166		-0.11	0.36	-0.10	.759		-0.31	0.11	-0.65	.014	

Table 22 below shows a strong and significant correlation between prompt 1 total score and spelling (r=.64, p<.001) Also shown are moderate and significant correlations between prompt 1 total scores and both of word reading (r=.56, p<.001) and reading comprehension (r=.52, p=.001). On the other hand, morphological awareness dynamic shows weaker but also significant correlations with each of spelling (r=.39, p=.015), word reading (r=.47, p=.003) and reading comprehension (r=.46, p=.003).

Table 22.

Correlations Among the Following Variables, all at Time 2: Prompt 1 Total Score, Prompt 1 Phonological Score, Prompt 1 Orthographic Score, MA Dynamic, Spelling, Word Reading and Reading Comprehension

Variables	1	2	3	4	5	6	7
1. Prompt 1 total	-	.95**	.59**	.59**	.64**	.56**	.52**
2. Prompt 1 phonological		-	.31	.64**	.53**	.45**	.49**
3. Prompt 1 orthographic			-	*.15*	.59**	.57**	.33*
4. MA dynamic				-	.39*	.47**	.46**
5. Spelling					-	.76**	.63**
6. Word reading						-	.77**
7. Reading comprehension							-

Note. Correlations are Bivariate (Pearson's r). All correlations significant at p < .05 marked by an asterix (*). All correlations significant at p < .01 marked by two asterixes (**). Nonsignificant correlations are in italics.

3.5 Discussion

The goal of this study was to examine the effects of morphological awareness in emergent readers, on subsequent literacy development a year later; namely, reading comprehension, spelling and word reading. Due to the importance of phonological awareness in reading development, it was measured, amongst other skills, to identify whether morphological awareness made an independent contribution to reading development. Thus, phonological awareness, word reading, vocabulary and morphological awareness were assessed as predictor variables at time 1 for their contribution to reading comprehension, word reading and spelling at time 2. Importantly, a novel phonological awareness task was created for this study to specifically control for the phonological knowledge necessary in the morphological awareness task. This was administered alongside standardised phonological awareness tasks. The main finding was that morphological awareness in the oral language of beginner readers contributed to reading comprehension a year later, when word reading was controlled (and vocabulary not controlled).

Analyses were carried out on both sets of morphological awareness data, the extended set of 18 items and the limited set of 11 items. In both cases, morphological awareness at time 1 only accounted for significant variance for reading comprehension at Time 2 and not any of the other time 2 literacy skills. However, the variance accounted for in the extended set (15%) was higher than in the limited set (10%). This inconsistency may be attributed to the extended set containing derivational items whilst the limited set only contained inflections. Inflections, unlike derivations, do not create new words but rather different forms of the same word (Marslen-Wilson & Tyler, 2007). Derivations, on the other hand, create completely new words with their own lexical identity. The extent to which derivations relate both phonologically and semantically to their root varies much more than it does for inflections. Consider for example the noun root ‘thought’ which combines with the suffix ‘ful’ to yield ‘thoughtful’. According to the Cambridge Dictionary (2020), the root word ‘thought’ refers to “the act of thinking about something to form ideas and opinions, or an idea or opinion produced by thinking”. ‘Thoughtful’ goes further to adopt a separate lexical identity referring to kindness to others. Thus, the ability to decipher these more complex and varied morphological transformations may link to the semantic and syntactic skills necessary for skilled reading comprehension. Nevertheless, it is clear that performance on both inflections and derivations contributed significantly to reading comprehension. Unfortunately, however, the sample size for the extended set is smaller (N=18) than the limited set (N=38). Thus, in the interest of conservative interpretation, the following discussion will be based on the core set analysis.

3.5.1 Reading comprehension

Overall, and largely in line with but extending previous research with older children, the findings here revealed that for very young readers, morphological awareness is more successful in predicting reading comprehension longitudinally, than word reading or spelling (Levesque et al., 2017). However, this result was only found when word reading is controlled and not when vocabulary is controlled. When vocabulary was controlled, this contribution was not found.

It seems clear from the findings in this study that at an early age, the role of morphological awareness in reading comprehension is linked to vocabulary. Tasks of morphological awareness which require participants to focus on meaning relations may best predict reading comprehension (Apel et al., 2013). This is in contrast to findings by Deacon et al., (2014) who found that morphological awareness supports reading comprehension directly through language skills, and indirectly through word reading skills (mean age 8 years, 11 months). Further, in children of similar ages, Levesque at al., 2017 failed to find a moderating role of vocabulary in the relationship between morphological awareness and reading comprehension. The current study examined younger children. Perhaps, in early stages of literacy acquisition, any contribution of morphological awareness to reading comprehension is based on word-level lexical factors. These findings are consistent with The Morphological Pathways Framework described in Levesque et al. (2020). According to this model, morphological awareness links to reading comprehension via three pathways. The first pathway begins in the linguistic system moving through word reading to reading comprehension. The second pathway begins again in the linguistic system, moving this time through the lexicon to reading comprehension. The third pathway offers a direct link between morphology and reading comprehension in the linguistic system. Of critical importance here is the notion that the path from morphological awareness to reading comprehension development begins in the linguistic system and moves through the lexicon. By studying this skill, undisturbed by orthographic skills, in the oral language of beginning readers, it is demonstrated that in young learners, the value of morphological awareness in supporting reading comprehension is related to the lexicon.

3.5.2 Word Reading

Another important distinction to consider is that of morphological decoding and morphological analysis. The former relates to morpho-orthographic processing of a word's form, while the latter relates to morpho-semantic processing of the word's meaning. In the current study, it may be argued that morphological awareness as a rudimentary variant of morphological analysis was used; in order to complete the oral sentence completion task, children had to access the semantic value of affixes to create morphologically complex target words. Then, it seems logical that morphological awareness in oral language would engage semantics in support of reading comprehension. What is less clear is whether or how early morphological awareness supports later morphological decoding and general word-level skills. The results found here seem to suggest at best a tenuous link. Time 1 morphological awareness contributions of 3% and 1% of unique variance to later word reading and spelling, respectively, were not significant. Although morphological awareness seems to have a greater link to reading comprehension, previous studies have found that it contributes to word-reading development (Deacon & Kirby, 2004; Kirby et al., 2012). Although not significant, the 3% contribution to variance found in this study, for example, is similar to the 2.6% found by Robertson and Deacon (2019). Children may use morphological awareness indirectly via morphological decoding (Levesque et al., 2020). Certainly, compelling evidence has mounted to show that morphological awareness aids reading development through increased lexical representations (Kirby & Bowers, 2017), top-down semantic activation (Verhoeven & Carlisle, 2006) and by using morphemes as more efficient 'chunking units' (Dawson et al., 2018). However, the results found in this study suggest that morphological awareness may not support reading development from an even earlier age.

One confounding issue that further research could elucidate, is the lack of morphologically complex words present in the standardised reading tests used. If morphological awareness is linked to word reading though decomposition of morphologically complex words, then this effect will be missed in monomorphemic words. Consequently, a weaker effect may be found.

3.5.3 Spelling

This issue of a lack of morphologically complex words was addressed in the spelling task. Children were asked to spell base form words (e.g., *rock*), base form words embedded within a longer control word (e.g., *rocket*), and the base form embedded with a morphologically complex word (e.g., *rocking*). Yet, morphological awareness contributed the least amount of unique variance to the spelling task. Previous research has demonstrated that awareness of morphological structure facilitates the spelling of morphologically complex words (Breadmore & Deacon, 2019; Kemp, 2006). Nevertheless, little research has longitudinally investigated the time course of this pathway from such a young age.

While it seems clear that children do use morphological awareness online during the spelling of morphologically complex words, the skills involved in the task of the current study may have tapped more semantic knowledge. Thus, the value of this skill as a developmental predictor of spelling accuracy may have been dominated by other word-level skills such as word reading and phonological awareness. It seems then, at least at this age, that morphological awareness is more directly involved in the development of morpho-semantic than morpho-orthographic processes. This seems natural at a developmental stage where phonological instruction is largely used for word decoding.

This does not, though, necessarily rule out the likelihood that morphological awareness is more generally linked to spelling. When vocabulary, and not word reading was controlled, morphological awareness contributed 21% variance to spelling a year later. Indeed, older children, from approximately age 7, may be able to use more cognitively challenging processes in carrying out spelling tasks, drawing on general links to morphological awareness (see for example, Deacon et al., 2009). For example, children could use their knowledge of past tense endings -ed and rule these out for monomorphemic nouns (e.g., killed vs kilt). Conversely, very young children may rely more on rote memory and/or phoneme-grapheme correspondences, precluding the need for any associations to morphological knowledge.

Notably, word reading was the only time 1 variable to demonstrate a significant contribution to spelling at time 2. Meanwhile, phonological awareness (and surprisingly not word reading at time 1) was the strongest predictor of word reading at time 2, although this significance was marginal (*p*=.055). This pattern would indicate that phonological awareness supports word reading which in turn supports spelling. This finding is consistent with a plethora of studies which have found that phonological awareness is one of the most important early skills for later word reading (Carroll et al., 2003; Hogan et al., 2005; Stahl & Murray, 1994), particularly in the first two years of school (Kirby et al., 2003).

3.5.4 Morphological Rule: Concurrent Links

In order to examine deeper and more abstract understanding of morphology, children were given question prompts regarding the morphological rule for each item. The proportion of correct answers to prompt 1were recorded at time 2. Morphological rule knowledge was found to be significantly correlated with spelling (r=.64, p<.001), word reading (r=.56, p<.001) and reading comprehension (r=.52, p=.001). Dynamic morphological awareness at time 2 showed weaker yet significant concurrent correlations with each of spelling (r=.39, p=.015), word reading (r=.47, p=.003) and reading comprehension (r=.46, p=.003), all at time 2. As expected, the morphological rule concept appeared to be more closely linked with all of the literacy measures studied, pointing perhaps to an explicit knowledge of language and its rules (Carlisle, 2000). This meta-linguistic awareness could be an underlying skill which is shared across all the measures studied.

An unexpected finding was that the morphological rule concept was most strongly correlated with spelling and least strongly correlated with reading comprehension. This finding, might at first, appear at odds with those discussed in the discussion paragraphs above. Namely that morphological awareness at time 1 demonstrated the highest predictive power for reading comprehension at time 2 than spelling or word reading. However, two discrepancies are important to note in dissecting this issue. Firstly, the relationships explored between prompt one and the literacy skills are cross-sectional and at the later time point. Indeed, several studies have found concurrent links between morphological awareness and spelling in older children as replicated in this study (Deacon et al., 2009). This study does go a step further by testing the longitudinal relationship between morphological awareness at an early age and literacy measures a year later. It appears then that while early morphological awareness is predictive of reading comprehension, it is only related to spelling later on. This seems intuitive. While reading comprehension relies on skills from both oral and written language, spelling relies on orthographic knowledge. Older children may use insight into the orthographic structure of morphemes to support their spelling (Apel & Lawrence, 2011; Rispens et al., 2008). Younger children, conversely, may not be able to access this insight whilst grappling with smaller language units such as phonemes (Carroll et al., 2003).

Prompt 1 was specifically created to tap more explicit understanding of morphological rules. The ability to carry out deeper analysis of the morphological structure of words may aid in children's consolidation of lexical memory (Breadmore & Deacon, 2019).

3.5.5 Limitations and Future Directions

This study had limitations which could be addressed in future studies. The morphological awareness task used, although aimed at beginning readers, showed ceiling effects at time 2. Because of this, the task did not reach its potential in discriminating between different levels of skill in morphological awareness. It may be argued that this was exacerbated due to the stimuli employing real words instead of non-words. Yet, the semantic component of real words is an integral aspect of morphological knowledge. Future studies may use the task for even younger children with little to no reading capabilities (e.g. 3-4-year olds) to even further separate morphological awareness ability from orthographic skills. At this age, there may also be little input from phonological awareness or word reading which might highlight the direct pathway between morphological awareness and reading comprehension.

Another limitation was the lack of morphologically complex words used in the word reading task. The unique contribution made by morphological awareness at 3% was comparable to other studies (Robertson & Deacon, 2019). Yet, the contribution found here was not significant and may be more of a general association. A greater contribution may be found by using a higher proportion of morphologically complex words in the reading task.

Finally, a larger sample size might have increased the size of the effect. Due to the length of the Morphological Awareness task and the distractive nature of the school environment, several children were unwilling to complete the task at Time 1 (spring/summer of reception). Though, this was certainly not an issue the following year. For the task to be administered to even younger children, the smaller subset of 11items could be administered.

3.5.6 Conclusions

To conclude, this study was one of the first to investigate how oral morphological awareness in very young beginning readers (4-5-years) contributes to literacy measures a year later. In so doing, it has added to the knowledge about the beginning of the developmental time path of morphological awareness. Specifically, morphological awareness in the oral language of beginning readers contributes greatly to reading comprehension. Further, at this age, this contribution seems to be moderated by phonological awareness and not word reading as has previously been observed in older children. For slightly older children (5-6 years), on the other hand, more explicit knowledge of morphological rules was concurrently related to spelling, word reading and reading comprehension.

4 Base and Surface Frequency Effects of Morphologically Complex Words

4.1 Abstract

In the previous chapter, early morphological awareness was explored in the language of pre-literate children during their introduction to formal literacy. Children first gain knowledge about morphemes in oral communication, leading to their navigation of written text which is rich in morphologically complex words. Perhaps, sensitivity to morphological structure aids in children's reading of these morphologically complex words. Yet correlational studies cannot explain why or how morphemes are used during reading. Therefore, to test this hypothesis, the current chapter assessed morphological processing during reading in older literate children (experiment 1) and adults (experiment 2). Specifically, the chapter sought to identify the extent to which children might use morphological analysis, when this analysis might be most beneficial, and the role of morphological analysis within the context of other types of information such as orthography. Chapter four aimed to provide evidence that morphological decomposition processes support children's deciphering of morphologically complex words. Base and surface frequency effects in morphologically complex words were dissected to identify the role and underlying mechanisms of morpheme analysis. Findings revealed surface frequency effects for both adults and children. Base frequency effects were found for children during reading of morphologically complex words within sentences. This provides evidence for decomposition in children's morphological processing.

4.2 Introduction

Research has shown that morphological processing plays a role in word reading (Carlisle, 2000). It is important, however, to make the distinction between this indirect link and the tangible use of morphological processing in word reading. Morphological awareness is important in its parallel development with a host of other skills, whereas morphological processing is uniquely useful in the analysis of single words within the context of a sentence. Whereas morphological awareness requires effortful and explicit consideration of morphemes (Apel, 2014), morphological processing is more concerned with the implicit usage of morphological knowledge for word retrieval and production (Verhoeven & Perfetti, 2011). In word reading, morphological processing refers to sensitivity to the morphemic structure of the word (Carlisle, 2000). It has been shown that this sensitivity to morphemic structure is related to more efficient word reading. Children read more accurately on shift than transparent words (Carlisle, 2000; Carlisle & Stone, 2005), on derived (e.g. dancer) than pseudo-derived (e.g. dinner) words (Laxon et al., 1992) and on words with high family frequency and base frequency (Carlisle & Katz, 2006).

In assessing how morphology is used in reading, research has generally taken two avenues: One method compares effects of base and surface frequency, while the other method seeks to untangle morphological effects from those of the shared form (orthographic and phonological effects). Base frequency refers to the frequency of the word's stem only in oral language (e.g. *compute* in *computer*) (Taft, 2004). Surface frequency refers to the frequency of the whole morphologically complex word (e.g. *computer*). Finally, family frequency refers to the cumulative frequencies of a set of morphologically related words (De Jong IV et al., 2000). Both paradigms investigate the role of morphology in reading with subtle but important differences. The former elucidates the role of morphological constituents (via base frequency) in decoding the whole word (surface frequency) (e.g., Pollatsek et al., 2000). The latter elucidates the role of morphological information in word parsing, untangling its effects from phonological and orthographic information.

A key aim of the current thesis is to investigate morphological processing during reading of sentences. This was achieved using a two-pronged approach via two different studies in chapters four and five. The present chapter explores frequency effects of both the whole morphologically complex word (surface frequency) and its base (base frequency). Chapter five explores the usefulness of morphological and orthographic information in priming a morphologically complex word. Evidence from this might highlight children's sensitivity to the morphological structure of words.

Traditional methods have used the lexical decision task to evidence frequency effects (Ford et al., 2010). In particular, base frequency effects suggest sensitivity to the internal morphological structure of words. Traditionally, priming studies have been employed which show that morphological priming facilitates the processing of morphologically complex words. Again, reinforced is the notion that attending to the morphological structure of words is important for reading. In the following chapters, younger developing readers are compared to competent adult readers to identify whether there are differences in the extent of morphological processing during reading. This provides information about the developmental progression of morphological processing, as well as key differences between developing and skilled readers. Moreover, using the eye tracker provides richer, more naturalistic data.

4.2.1 Eye Movements during Reading

Studies of eye movements during reading have resulted in the formulation and support of key theories on the encoding of morphologically complex words (Bertram, 2011). Traditional methods for investigating morphological processing during reading include naming, lexical decision, sentence completion and word comprehension tasks. Naming tasks require participants to rapidly name or orally produce letter strings or pictures representing words (McBride-Chang et al., 2005). Lexical decision tasks require participants to make a decision about a given characteristic (e.g., grammatical viability) of a letter string by pressing one of two buttons (Dawson et al., 2018). Recently however, some researchers have also used eye-tracking paradigms for several reasons.

First, eye-tracking provides an online measure of the cognitive processes which occur during the reading of morphologically complex words (Blythe & Joseph, 2011). Second, morphological processing may be assessed with greater ecological validity than tasks such as lexical decision, although with similar effects as naming (Rayner, 1998). Participants are often asked to read morphologically complex words embedded within sentences, affording context and experimental conditions which closely emulate natural reading. Morphology is influenced by the lexical and sublexical processes in word reading. Yet, morphological structure also informs, and is informed by sentence-level features such as grammatical agreement. For example, take the sentence 'There are fruits in the bowl'. The auxiliary verb 'are' gives the reader a clue to the impending plural inflection 'fruits'. Thirdly, eye-tracking provides the unique opportunity to assess the time course of morphological processing (Pagán et al., 2016). For example, one can analyse eye-tracking data before (parafoveally), during (foveally), and after the initial reading (re-reading) of a given target word. Again, this is important for analysing the morphologically complex word within the context of the sentence within which it is embedded. Finally, eye-tracking provides an implicit and inherently subconscious measure of morphological processing (Bertram & Hyönä, 2003). Thus, the current study used the eye tracker to explore frequency effects in morphological processing in order to examine this process in adults and children.

It is important to consider how eye tracking might tap cognitive process, particularly reading. Decades of research has been carried establishing this topic (see Rayner, 1998 for a review). When we read a sentence, our eyes don't just glide seamlessly over the words.

Instead, our eye movements are comprised of a combination of fixations and saccades (Rayner, 1998). Saccades are the continuous movements made between different points that grab our attention. Fixations occur between saccades, when our eyes are relatively still and focusing on a character. Typically for English speaking adult readers, fixations are between 60 and 500 ms long and last for an average of 250 ms (Morrison & Rayner, 1981).

When reading English, readers move their eyes from left to right, roughly 85% of the time, and right to left 15% of the time (Liversedge & Findlay, 2000). Effective reading progresses forward from left to right and can include regressive saccades. Regressive saccades occur when readers misanalyse sentences and must move their eyes backwards to re-analyse material more deeply (Françoise Vitu et al., 1998).

Whilst most words are processed within just one fixation, some longer words may require two or more. Word skipping occurs when a word does not receive any direct fixations on the first pass. Often (about 1/3), very short, and predictable words such as ‘the’ are skipped altogether (Rayner, 1998; Rayner et al., 2003). Further, it is worth noting that word length and word predictability contribute strongly and independently to word skipping and fixation (Rayner et al., 2011). High-frequency words also influence word skipping although this effect is smaller than those found for word length and predictability (Brysbaert et al., 2005). As expected, there is an interaction between word predictability and word frequency, with the word-skipping effect of predictability being constrained to high frequency words (Rayner et al., 2004). Finally, bisyllabic words are skipped more frequently than monosyllabic words of the same length, despite similar fixation times (Fitzsimmons & Drieghe, 2011).

If a word is not skipped, the first fixation is usually located from the beginning to the middle of the word (Rayner, 1979). This so-called landing position contributes to within-word eye-movement tactics (i.e., the number of fixations made within a word) for both isolated words and continuous text (Vitu et al., 1990). Several studies have supported the view of an optimal landing position at the beginning to the middle of the word (Rayner, 2009).

4.2.2 Eye Movement Measures

In the study of lexical and syntactic processing, researchers have developed various eye movement measures with important implications for interpretation. Word frequency, in particular, produces robust effects in eye fixation durations for both adults (Juhasz et al., 2006; Vitu et al., 2001) and children (Joseph et al., 2013). Eye movement measures differentially convey information about the time course of lexical processing.

Specifically, distinctions can be made between measures which manifest early and late processing effects (Hyönä et al., 2003). Early eye movement measures point to immediate effects usually linked to lexical and sublexical processing. These measures are concerned with only the earliest fixations on a target word, often preceding refixations (e.g., first fixation duration) and fixations on words in the latter part of the sentence (e.g., gaze duration). Refixations refer to those fixations made to a word which follow the first one and precede movement to another word (Rayner et al., 2000). The earliest eye movement measure is first fixation duration which is the duration of the first fixation to land on a target word. In terms of morphological processing, Beauvillain (1996) found first fixation duration effects for base frequency but not surface frequency, suggesting lexical access as a function of the root's position within a word. Arguably the most popular eye measure is gaze duration, another early index which includes any fixations on a target word which precede eye movements exiting the word (Staub, 2015). Thus, the key difference between first fixation duration and gaze duration is that the latter allows the reader to re-fixate on the word. While first fixation duration taps immediate lexical effects, gaze duration indexes the whole word. Late measures index syntactic processing. Go-past duration refers to all fixations on the target word preceding saccades to the right (Hyönä et al., 2003). Thus, go-past duration critically indexes fixations on the word after the reader has had a chance to re-read the beginning of the sentence. Finally, total time duration refers to the total sum of all fixations landing on the target.

Importantly, eye movement measures allow for interpretation of the time course of morphological processing. Rau et al., (2015) studied the lexical processing of German and English children and adults using first fixation duration and gaze duration. Word length and surface frequency were manipulated. While German and English children yielded comparable total looking time at the target word, the mechanisms used were different. German children showed longer first-pass time and less re-reading while English children showed shorter first-pass time and more re-fixations. The authors suggested from this evidence that while English children may successfully use larger grain size processing strategies for high frequency words, the same strategy results in re-fixations for low frequency words.

4.2.3 Developmental Changes in Eye Movements during Reading

Blythe (2014) argued that it is imperative to consider the development of both cognitive processes and eye movement patterns in order to understand reading skill progression. In adults, much is known about eye movements and reading. Far fewer studies have been published regarding its development (Rayner, Ardoin, et al., 2013).

Children have shorter fixation durations and make fewer fixations and regressions per sentence than adults (McConkie et al., 1991; Rayner, 1979; Taylor, 1965). These patterns change with age and it is difficult to determine whether this is due to increases in reading skill or broader cognitive development. However, it may be argued that differences in eye movement behaviours between children and adults correspond with key differences in the cognitive processes involved in reading, and the two must be considered in tandem.

In any case, most studies support the view that eye-looking patterns reflect the relative difficulty of the studied text (Blythe, 2014; Hyönä & Olson, 1995). For example, studies have found that the use of complex texts provoke a change in adults' eye-movement behaviour akin to patterns reported in children (Blythe et al., 2009; Montag & MacDonald, 2015). Similarly, most researchers now agree that dyslexic children and typically developing children of the same age display similar eye movement patterns in reading, modulated by text lexical properties relative to cognitive function, and not oculomotor dysfunction (Hyönä & Olson, 1995; Olson et al., 1983; Zoccolotti et al., 1999). In the following sections, saccades, and word fixations will be discussed as eye movement behaviours which change from the beginner reader to the skilled adult reader.

4.2.4 Developmental Changes in Measures of Word Fixation Duration

Debatably, the most meaningful measures of parafoveal and foveal word processing are measures of word fixation duration. Children tend to require more fixations for longer words than adults. This is perhaps not surprising due to them also having a shorter perceptual span and longer fixation durations (Bucci & Kapoula, 2006; Parker et al., 2019).

Measuring fixation duration provides insight into how surprising a word might be. In word and sentence predictability studies, more surprising words are fixated longer (Joseph et al., 2008; Rayner et al., 2012). Crucially for developmental issues, fixation duration also gives insight into how difficult to read a word might be, with longer fixation duration equated to lexical processing speed (e.g., Joseph et al., 2013). In this vein, longer fixation duration and/or more fixations are evident for lower frequency words (Joseph et al., 2013), longer words (Hyönä & Olson, 1995; Joseph et al., 2008) and ambiguous words with distinct meanings (Albrecht Werner Inhoff & Rayner, 1986), among other lexical properties. This highlights the importance of lexical properties in the child's reading efficacy, and the ability of word fixation as a metric in untangling these.

Finally, children show different temporal patterns in fixation than adults. For example, Joseph et al., (2009) found that while adults and children did not differ in early fixation measures (e.g. landing position), stronger word length effects were found for children using later fixation measures (e.g. total time duration). Access to the time course of fixation patterns is invaluable in highlighting differences in reading skill and strategies across different age groups in literacy development (e.g., Rayner et al., 2009).

In summary, adults and children certainly present different eye-tracking patterns in reading with adults showing more efficient eye-movement behaviours. From the age of seven, children's eye movement behaviours accurately reflect cognitive processes and the efficiency of these behaviours (e.g. decreasing fixation durations, increasing words skipped and saccadic amplitude) gradually increase until approximately the age of eleven (Chen & Tsai, 2015).

Also, it seems likely that some of these eye movement behaviours are linked; for example, smaller perceptual spans lead to shorter saccades and more fixations on words (Clifton Jr et al., 2007). Key questions that arise are whether these differences are attributable to ocular motor functions or reading skill, and about the direction of causality between these eye-movement behaviours and reading skill. In answering these questions, it appears that evidence from eye movements in reading converges on the notion that eye movement behaviours are closely linked to the perceived difficulty of the text in question (Blythe, 2014; Blythe & Joseph, 2011; Albrecht Werner Inhoff & Rayner, 1986). Indeed, Rayner et al., (2006) argued that eye movement behaviours reflect differences in comprehension processes in reading. Nevertheless, oculomotor function must also be considered as perhaps a secondary contributing factor to eye movement differences between adults and children. Further research carefully controlling text difficulty, chronological age, and oculomotor control is needed for more conclusive answers (Blythe & Joseph, 2011).

What is clear from past research is that eye movement data is a valuable investigative tool into the cognitive processes that underlie reading mechanisms in children and adults (Blythe, 2014). Using this, base and surface frequency effects may be examined to explore morphological processing within the context of sentence reading. This will be discussed further in the sections that follow.

4.2.5 Base Frequency Effects on Reading

4.2.5.1 Adults

Although much remains underspecified with regards to processing morphologically complex words, clear consensus has been obtained on one key issue: decomposition effects are stronger for low compared to high frequency words for skilled readers, all else being equal (Lehtonen & Laine, 2003; Schreuder & Baayen, 1995; Taft & Forster, 1976).

Support for the use of morphological analysis in reading morphologically complex words has come from a wealth of naming and lexical decision studies examining frequency effects on word reading (Niswander et al., 2000; Taft & Forster, 1976). By manipulating the frequency of the whole word (i.e., surface frequency) to the frequency of the stem (i.e., base frequency), researchers are able to tease apart whole word and constituent effects of morphologically complex words (Rastle & Davis, 2003). The idea here is that if surface frequency is controlled, any base frequency effects found may be due to decomposition of the word into its constituent morphemes during reading. For example, theories such as the Morphological Framework Pathway (Levesque et al., 2021) may predict that a low base frequency word (e.g., impairment) may take longer to process than a high base frequency word (e.g., dryness). Importantly, surface frequency must be controlled between these words in order to partial out its effects.

One of the first studies to find a base frequency effect in the processing of English morphologically complex words was Taft (1979). Using a lexical decision task on adults, it was found that high base frequency yielded lower response times during word recognition when surface frequency was controlled, and that high surface frequency yielded lower response times when base frequency was controlled. It is important to note, however, that in this study base frequency was described as the summed frequencies of related forms (e.g., the sum of all of the frequencies of each of the target's morphologically related words). Nevertheless, both forms of morphemic frequency effects may be taken as evidence for the claim of morphological representation due to very high correlation (Ford et al., 2010).

As in lexical decision and naming studies, eye-tracking studies have found strong effects for word frequency on processing of morphologically complex words (Blythe et al., 2009; Joseph et al., 2013; Valle et al., 2013). Rayner and Duffy (1986) found that participants fixated longer on infrequent words than more frequent controls. Much of the research carried out on the processing of morphologically complex words has been in Finnish (Staub & Rayner, 2007). These studies support a morpheme-based route for reading. However, notably, Finnish, as compared to English is richer in morphological complexity. That is, Finnish contains more morphologically complex words, and. Many of these words contain more morphemes than are generally found in English. Thus, it may be argued that morphological decoding is more advantageous for the former (Kidd & Kirjavainen, 2011). Yet, Vannest et al., (2002) found exactly the opposite. Lexical decision tasks showed that English required more morphological parsing than did Finnish. This is perhaps due to the scarcity of tri-and quadro-morphemic words in English as compared to Finnish. The authors argued that computational demand for morphological decoding of bimorphemic words, which are more abundant in English, may be less than for the tri-and Quadro-morphemic words in Finnish.

In the current thesis, base and surface effects were explored to examine decomposition. Base frequency is distinct from morpheme family size, which refers to the type count of words (derived and compounds) in which the base morpheme appears as a constituent. It appears that base frequency is highly indicative of decomposition processes. Schreuder and Baayen (1997) suggested that discrepancies in research papers regarding the presence or absence of morpheme frequency effects may be due to confounds between morpheme family size and base frequency. Further, morphological family size has been shown to have an independent relationship to morphological processing in Dutch (De Jong IV et al., 2000).

Crucially, in terms of the relationship between each of these measures and morphological analysis, there is strong evidence to suggest that base frequency, and not morphological family size, is predictive of morphological analysis. Ford et al., (2010) used lexical decision tasks to compare the relationship between morphological family size and base frequency on response latencies to derived words with productive (e.g. -ness) and non-productive (e.g. -age) suffixes. Productivity was taken to mean those suffixes which showed greater consistency in the mapping of form and meaning, fewer grammatical functions and predominantly transparent forms. The findings revealed that morphological family size influence response times, irrespective of productivity. Conversely, there was a significant interaction between base frequency and suffix productivity whereby base frequency only influenced response times for derived words with high productive suffixes. From this, it is clear that both morphological family size and base frequency influence the reading of multimorphemic words. Ford et al., (2010) argued, then, that whereas morphological family size effects draw on semantic connections, base frequency effects are underpinned by morphological processing. The study provided evidence for the notion that the relative importance of morphological processes in word recognition is strongly linked to the lexical properties of each individual word. Further, base frequency, was shown here to be one such important lexical property in highlighting morphological processes. Nevertheless, Ford et al.,

(2010) conceded that whole word effects were greater than base frequency effects. Thus, further research is warranted to investigate the mechanisms by which base frequency might highlight morphological processes in word recognition.

Indeed, there has been criticism of this assertion for the importance of base frequency, and some studies have found an absence of base frequency effects. Taft (2004) for example, did not find an effect of base frequency in a lexical decision task in English-speaking adults where surface frequency was controlled while comparing low surface/high base frequency words to low surface/medium base frequency words. However, the author asserted that the ratio between the low surface and medium base frequency in the LSMB words might not have been sufficient to yield an effect.

Baayen et al., (2007) contended that although there might be a marginal role for base frequency, surface frequency plays a significantly more important role in multimorphemic word processing. In their study, using lexical decision and naming, surface and not base frequency was found to be an important predictor of reaction times for three of the four tasks.

Importantly however, base frequency was found to be a significant predictor of reaction times in visual naming-one of four tasks. Visual naming is unique from the other tasks used in this study and arguably, the only task that might be expected to show a base frequency effect. The tasks used were the naming tasks, where participants were required to repeat the word presented, and lexical decision tasks, where participants were required to press separate buttons for real and pseudowords. These tasks were further separated as visual (reading the target word presented on-screen) and auditory (hearing a word). The visual naming task, therefore, is the most likely to tap normal reading processes two-fold. By virtue of using visual input rather than auditory, the process of word recognition is clearly linked to word reading. Secondly, by requiring the participant to repeat the word, we are assured that they have fully processed the word in a similar way to reading. For lexical decision, on the other hand, the participant might have relied on other strategies to make a decision.

Lexical decision tasks invoke loads on memory which mean they are sensitive to memory traces of morphologically complex words but not the internal morphological structure (Clahsen & Neubauer, 2010). Therefore, it is expected that surface frequency effects might supersede base frequency effects in lexical decision tasks due to the nature of the task. Participants are asked to make decisions as quickly and accurately as possible, precluding opportunities for word parsing and access to the base. Indeed Schilling et al., (1998) found an enhanced surface frequency effect for lexical decision over eye-tracking and naming perhaps highlighting the salience for surface frequency in lexical decision tasks.

It is also expected that base effects might be more important for visual than auditory processes. Recognition of morphological boundaries are greatly enhanced by processes in orthography analysis (Rastle & Davis, 2008), which is more relevant for visual than auditory tasks. Therefore, this study provides evidence for the importance of morphemic representation in the reading of low surface frequency words.

Yet even naming studies do not reflect the true process of word reading due to words being processed in isolation and without the context of a sentence. Joseph et al., (2013) argued that methodologies which require the participant to pronounce words aloud are in stark contrast to what actually occurs during reading. During naming the participant simply pronounces a single word in isolation, whilst during natural reading, words are read within a sentence.

Moreover, Nation (2008) made the distinction between offline and online measures. Whereas offline measures such as lexical decision and naming tasks records the end result of reading, online measures such as eye-tracking track the temporal sequence of reading. This provides the opportunity to better understand the cognitive processes occurring during reading. The current study elucidated the role of frequency effects as reflected in naturalistic reading of morphologically complex words embedded within sentences.

4.2.5.2 Children

An important research avenue to consider is the developmental progression of morphological processing during reading. Yet there remains a dearth of research in this area (Joseph et al., 2013). One key question would be whether children, with their developing reading skill, process morphologically complex words in the same way that adults process comparatively difficult text. Gaining evidence into how they differ might also highlight differences and similarities in multimorphemic word processing strategies and how these develop.

However, unlike in adults, where the word (i.e., surface) frequency effect has been established (Rayner, 1998), there does not seem to be a clear consensus on whether children demonstrate word frequency effects during sentence reading (Joseph et al., 2013). Whilst some studies have found clear and reliable word frequency effects similar to those observed in adults (e.g., Blythe et al., 2009), others found none (e.g., Blythe et al., 2006; Juhasz et al., 2006). However studies varied methodologically (e.g. silent and oral reading) and often failed to control for associated variables such as age of acquisition, corpus used, and sentence frames (Joseph et al., 2013).

The lack of surface effects for children may also be due to a lack of power in some experiments. Recording eye movements during reading often involves several trials of continuous sentence reading which is tiring for young children (Blythe et al., 2006). For example, Blythe et al., (2009) found surface frequency effects with 32 child participants whilst Blythe et al., (2006) failed to find surface frequency effects with 12 children. Addressing these issues, Joseph et al., (2013) found clear and reliable frequency effects on eye movement measures in 8-year-olds during the silent reading of sentences. This study supports models such as the E-Z Reader which asserts that text features continuously influence eye-movement patterns (Pollatsek et al., 2006; Reichle et al., 1999).

Whilst this and other studies have contributed significant information regarding word reading using the eye movement measures, no study to date has specifically focused on the developmental progression of the frequency effect in the processing of morphologically complex words in this way. Yet, as discussed above, morphological decoding becomes critical during the trajectory from learner to skilled reader. Further, given the evidence that children's eye movements respond to text difficulty (Joseph et al., 2013), manipulating base and surface frequency in morphologically complex words should evoke relevant changes in eye movement behaviour. These, in turn, would provide a wealth of information regarding how the recognition of morphemes might affect the processing of morphologically complex words.

In a practical sense, investigating the influence of base frequency effects on morphological processing might be even more important for the developing reader. In school, children are expected to read and comprehend increasingly difficult texts and are confronted with an increasing number of complex multimorphemic words (Nagy & Anderson, 1984). Tong et al., (2011) found that three matched groups of readers in Grade 5 (unexpected poor comprehenders, expected average comprehenders, and unexpected good comprehenders) did not differ on phonological awareness, naming speed or orthographic processing tasks, but differed on morphological awareness, even after statistical controlling for vocabulary. Morphological awareness is a sensitive index for a child's reading comprehension suggesting an important role for morphological analysis in their reading.

Several researchers argue that knowledge of the root might be instrumental in deciphering these complex words, that are so often encountered in printed school English (e.g., Kieffer & Lesaux, 2012; Nagy & Anderson, 1984). This skill, generally referred to as morphological analysis, involves the retrieval of words by accessing and analysing their constituent morphemes.

Of note, it has been asserted, and supported by data, that there is a distinction between morphological analysis of unfamiliar words versus previous encounter and whole word lexical representation (Anglin et al., 1993). Deacon et al., (2017) found a significant base frequency effect in a task that required Canadian Grade 3 (mean age=8.93 years) and Grade 5 (mean age=10.94 years) children to define morphologically complex words. Importantly, surface frequency was controlled in the stimuli. Although main effects of base frequency and age were found (with better performance for high base frequency and older children), the interaction between these effects was not significant. In other words, both age groups used morphological analysis to the same extent. However, this study did not examine whether the patterns observed in children were the same as those found in adults.

A key aspect of the current study is understanding the developmental trajectory of morphological analysis from children to adults. One pertinent question that arises from this is whether children and adults use morphological analysis to differing extents and how this might change with developing reading skill. Lázaro et al., (2013) investigated the base frequency effect in children with reading disorders (mean age =8.21 years), chronological age matched skilled readers (mean age=94.1) and vocabulary size matched skilled readers (mean age=7.08 years) using a lexical decision task. The base frequency effect was only evident in the chronological age matched skilled readers perhaps indicating that morphological analysis is absent in children younger than 7 or 8 and develops with reading skill rather than age per se. Also, important to consider, is that tasks from the above studies might vary in their sensitivity to morphological analysis with the definition task allowing children more time to consider their answers and tapping the semantic aspect of word identification (as opposed to phonological alone).

In any case, taken together, the studies discussed above provide convincing evidence that base frequency effects may be found with children as with adults. However, there is not a clear consensus on this. A lack of effect for base frequency has also been evident in developmental studies using other paradigms. For example, Carlisle (2000) assessed 10-11-year-olds word reading accuracy of high and low surface frequency derived forms. Base forms were matched for frequency (high). It was hypothesised that if words were decomposed into morphemes prior to pronunciation, there would be no difference between accuracy on high and low surface frequency words. The results, however, showed that high surface frequency words were read more accurately than low surface frequency words, with no evidence of moderation from base form frequency.

Importantly though, it is crucial to identify the circumstances in which a decomposition strategy might be favoured over whole-word access (Taft, 2004). For example, are words never decomposed, all decomposed or is this strategy reserved for less familiar words (e.g. low-frequency)? Further, if the latter is true, it surely follows then that only the more familiar (high frequency) bases would yield an effect.

In order to assess the unique role of base frequency in morphological decomposition, it needs to be separated from surface frequency. That is, in both of the above studies, surface frequency effects might have been confounded with base frequency effects, because only surface frequency was manipulated in the design. It must be acknowledged that surface frequency is likely to have greater impact on reading than base frequency. After all, it is well established that whole word lexical access is the most efficient pathway to word processing in adults (Castles et al., 2018; Verhoeven & Perfetti, 2011). However, there may exist specific but abundant situations in which base frequency also exerts an influence on reading.

Based on the Morphological Pathways Framework, the effects of morphological decoding may be more apparent for low frequency words and thus beholden to morphemic structure (Levesque et al., 2020). Therefore, in assessing decomposition, it is critical to manipulate both surface and base frequency as they modulate each other (Amenta & Crepaldi, 2012). This might be particularly relevant for children whose word reading skills are developing and therefore encounter a large number of unfamiliar words, and similarly for adults reading particularly complex low frequency words.

The aim of this study was to investigate and untangle the effects of base and surface frequency in the reading of morphologically complex words. Hence, in investigating base frequency effects and its role in decomposition, three considerations were made. First, word frequencies were tightly controlled such that high base frequency has significantly higher base frequency than low base frequency words and high surface frequency words have significantly higher surface frequency than low surface frequency words. Second, both surface and base frequencies were manipulated in order to ensure a fuller understanding of the circumstances leading to pathway activation (decomposition vs whole-word) yielding four groups of words: high surface/high base (HBHS), high surface/low base (HBLS), low surface/high base (LSHB), and low surface/low base (LSLB). Third, eye-tracking data of target words within sentences were collected, more closely mimicking natural reading by involving visual rather than auditory stimuli and reading across a sentence, as opposed to a single word. Finally, to explore whether there are developmental differences in morphological processing, experiment 1 examines these effects in child participants and experiment 2 examines these effects in adults.

4.3 Experiment 1

It was proposed that children might read high and low surface frequency words differentially, depending on their base frequencies. Deacon et al., (2011) found that Grade 4 (mean age of 9 years, months) children were more likely to pronounce high base frequency words correctly irrespective of their surface frequency. Specifically, accuracy levels for low and high surface frequency words were higher when they also had high frequency bases compared to low frequency bases. This suggests that these children were using their understanding of the base morpheme to decipher the words and were thus sensitive to the morphological structure of the words. For Grade 6 children (mean age of 11 years, 6 months), base frequency moderated accuracy levels for low surface frequency words only. Ceiling effects for the high surface frequency words precluded their analysis. Presumably, children were able to read all of these higher surface frequency words without accessing their base words due to ceiling effects, thus washing out any base word frequency effects. Another notable finding was that base frequency effects for low surface words were stronger for the younger children (Grade 4 and 6) than for the older children (Grade 8). However, this finding may just be an artefact of the ceiling effects in older children.

An online measure such as eye-tracking might be able to highlight effects for these older children. Further, due to the ceiling effects, clarification is necessary as to whether there is a clear distinction between how children read high surface words of varying base frequency or whether high surface frequency words are accessed in their whole form irrespective of base frequency. This study aimed to elucidate these effects by using the eye-tracker to assess how children read these words in real time. Moreover, by expanding the age range to include younger children (from age 7), the aim was to examine whether there is a development trend of decreasing effect of base frequency on word reading as children get older. The eye-tracker should yield more sensitive measures than accuracy scores due to the reasons outlined in the introduction.

In the current study, the stimuli set from Deacon et al., (2011) was used to examine base and surface frequency effects in adults and children. Here, the target words were inserted into sentences to reflect more natural reading. Using the eye-tracker, looking time was recorded across four different eye movement measures: First fixation, gaze, go-past and total time durations. Comprehension questions were administered to ensure reading beyond a superficial level.

It was hypothesised that firstly, there would be a main effect of surface frequency – in this case, high surface frequency words would be looked at for significantly shorter periods than the low surface frequency words (irrespective of base frequency) (Blythe et al., 2009). This may be due to participants being able to directly access a high-quality lexical representation of the high frequency words. Secondly, a main effect of base frequency was also expected. Low base frequency words should yield a longer looking time than the high base frequency words. Thirdly, an interaction was expected such that base frequency effects are only apparent for low surface frequency words. If surface frequency is high, participants may need to attend less to the constituent morphemes and thus no base frequency effects would be evident. If surface frequency is low, participants may need to access the constituent morphemes and thus, there should be significantly longer looking at low base frequency than high base frequency.

In the current experiment then, no base or surface frequency effects were expected for first fixation duration as children attempt to process all words, irrespective of frequency, using the same initial large-unit strategy. There may be base- and surface-frequency effects for the middle-ground and later eye measures, gaze, go-past and total time durations. This could reflect the child's attempt to re-process low surface frequency words at a lexical level (indexed by gaze duration) and after contextual re-integration with the beginning of the sentence at a syntactic level (go-past and total time durations).

4.3.1 Experiment 1 Methodology

4.3.1.1 Participants

The child participants were tested at a free Science event for families held at Coventry University. Participants were invited to the event by social media, posters and through e-mails to teachers and parents from the research group's database. Thirty-eight children took part in the experiment. Of these, thirteen participants were excluded due to non-completion of the task (N=5), parent reported educational disabilities (N=4) and atypically poor reading (standardised TOWRE scores below ninety, N=4). Twenty-five participants remained for analysis (10 male, 15 female). Twenty-four participants completed the task and one completed 20 of the 32 items. Their ages were between seven and twelve years, and their mean age was 10 years, 2 months (standard deviation=18.67 months). According to parental report, all participants had normal or corrected-to-normal vision and no known hearing, reading or developmental difficulties. To ensure that participants did not have any reading difficulties, they were pre-screened with the Test of Word Reading Efficiency - Second Edition (TOWRE-2; Torgesen et al., 2012). This confirmed that participants had the age-appropriate levels of word and nonword reading ability (TOWRE: mean standardised score =108.33, SD=9.27, range=95-129).

4.3.1.2 Materials and Design

Thirty-two experimental sentences were specially constructed for this study. Each sentence contained a target morphologically complex word of 6-12 letters. Target words were taken from Deacon et al., (2011). Sentences were created for each word as Deacon et al., (2011) used the target words in isolation. This was a 2x2 design, crossing the within-subjects variables word surface frequency (conditions: high, low) and base frequency (conditions: high, low). There were eight words per condition resulting in 32 words. In Deacon et al., (2011), words were matched to ensure that words in each of the low base frequency condition (with high and low surface frequency) were similar in base frequency, as were those for high base frequency. The same analyses were carried out and controls were confirmed for the surface frequency. The number of letters, sounds and syllables were similar across the conditions, as well as the number of items with solely phonological changes (see Deacon et al., 2011 for details) for Table 23 shows the CELEX base and surface frequency scores for the four word conditions. See Appendix D for base and surface frequency scores of all 32 words. See Appendix E for the full list of target words and framing sentences.

Table 23.

CELEX Base and Surface Frequency Scores for Each of the Four Word Conditions

	High base, high surface frequency words	Low base, high surface frequency words	High base, low surface frequency words	Low base, low surface frequency words
Base frequency	93.13	2.5	90.43	1.75
Surface frequency	92.13	125.63	3.57	2.63

Eight quartets of target words were created. Every quartet contained one each of the four condition words (low base frequency and low surface frequency, low base frequency and high surface frequency, high base frequency and high surface frequency, high base frequency and low surface frequency). For each quartet, a sentence frame was created that was identical up to word N+1 (e.g., They took the [leader to make the plans.]/[computer to get it fixed.]/[developer to see the land.]/[offender to meet the judge.]). Four item sets were created with the items ordered randomly within each set. Each participant was presented with one of the four item sets in succession. Comprehension questions were administered after every four sentences, one for each quartet. Comprehension question were based solely on content presented within the stimuli items and did not require prior knowledge. Mean performance accuracy on the comprehension questions was above chance at 100% for all four word conditions.

4.3.1.3 Apparatus

Eye movements were recorded, and sentences were presented using ExperimentBuilder (version 2.1) on a 24-inch monitor at a viewing distance of 70 cm, with a refresh rate of 144 Hz and resolution of 1,024 by 768 pixels. Reading was binocular;

however, eye movements were recorded from only the right eye using an Eyelink 1000+. Participants were asked to place their heads in a chin/forehead rest to reduce movement. Sentences were presented in black, Courier New, size 12 font on a grey background in the middle of the screen; three characters subtended 1° of visual angle. A three-point calibration was used and repeated after every trial.

4.3.1.4 Procedure

In a separate testing session on the same day participants completed three background measures, namely the TOWRE-2, British Picture Vocabulary Scale 3 (BPVS3; Dunn et al., 2009), and Raven's Progressive Matrices (Raven, 1958). Participants also took part in other research experiments and non-experimental activities on the same day.

To complete the current experimental task, participants were asked to sit in a quiet room on a chair and a booster seat as necessary. A chin/forehead rest was used to minimise head movements. Participants were instructed to read each sentence silently and informed that comprehension questions would follow some sentences. A cross appeared on the screen directly before the presentation of each sentence. This was done to ensure that participants always fixated at the same position before reading each sentence. Immediately after reading each sentence, participants were asked to look to the bottom right corner of the screen which prompted the experimenter to press a key on the keyboard to progress to the next sentence. For every other sentence, participants were presented with a comprehension question to which they verbally responded Yes/No to progress. Each of the comprehension questions corresponded to the last sentence read and the participants could not review the sentence to assist with answering. Each sentence and comprehension question were presented one at a time in the middle of the screen. Participants completed drift correction after every sentence and the experimenter recalibrated as necessary. Participants were given a 3-minute break after reading half of the sentences. They were informed that they could take additional breaks as desired and that they were free to withdraw at any time. The eye movement experiment lasted approximately 25 minutes.

Ethical approval was gained from the Health and Life Sciences Research Ethics Committee at Coventry University prior to recruitment and data collection. Written consent was obtained from parents. Children provided oral assent and were reminded of their right to withdraw in child appropriate language.

4.3.2 Experiment 1 Results and Discussion

4.3.2.1 Data preparation

Trials were removed upon visual inspection of participants' eye-tracking. Thirteen of the children's trials were removed. Ten of which were removed due to the target word not being fixated. Further, three trials were removed as three or more words after target were not fixated. These were removed as the participant did not read the sentence completely. For all trials where the target was fixated, the preceding three words were also fixated.

Next, the eye-tracking data was readied for analysis using a 4-stage fixation cleaning process in DataViewer software (Version 3.1.246; SR Research Ltd., Ontario, Canada). This was done to amalgamate several short fixations close together, before removing those short fixations which were isolated. Firstly, fixations shorter than 80 ms were merged with others within one character space. Next, fixations shorter than 40 ms were merged with others within three character spaces. Finally, fixations shorter than 40 ms and longer than 1200 ms were removed (Breadmore & Carroll, 2018).

Eye movement measures were then extracted. Outliers were only removed for children only due to the variability that can occur with child eye movements and the large age range in the current study. Outliers were removed for those eye movement measures which required the summation of several fixations (i.e., go-past duration, total duration, and gaze duration). They were not removed for first fixation duration as these were already removed during the four-stage fixation cleaning process. Outliers were removed when they were more than 3 standard deviations away from each eye measure mean. This resulted in the removal of 1.55% of total durations, 1.31% of go-past durations and 1.75% of gaze durations.

4.3.2.2 Data analysis

The data was analysed in R (version 3.5.1; R Core Team, 2018) in R Studio (version 1.1.463; PBC, 2018) using linear mixed effects modelling with maximum likelihood using the lme4 package (Bates et al., 2015). Modelling was carried out with maximal random effects structure according to the guidelines reported in Barr et al., (2013). The full models included random intercepts for both participants and items. The within-subjects design of the study also enabled us to model random slopes for participants. Since no between-subjects factors were included in the study, random slopes for items are illogical and are not included. Thus, the full model initially yielded:

Dependent variable~Surface frequency*Base frequency + (1+ Surface frequency + Base frequency+ Surface frequency*Base frequency|Participant) + (1|Item)

The statistical significance of the contribution of each fixed factor (surface frequency and base frequency) and their interaction was tested using likelihood ratio tests on log transformed eye movement measures (raw durations are reported in tables and figures to aid interpretation). Full and null model likelihoods with identical random structures were compared. The interaction significance was assessed by comparing the full model including the interaction (surface frequency* base frequency) with the model of additive fixed effects (surface frequency + base frequency). The significance of surface frequency was assessed by comparing the additive fixed effects model with the null surface frequency model. Finally, the significance of base frequency was assessed by comparing the additive fixed effects model with the null base frequency model.

If any full, reduced or null models failed to converge, random slopes were removed uniformly from all models until convergence was achieved in the following order. First the interaction slope was removed to yield + (1+ Surface frequency + Base frequency |Participant). Next, the factor with less theoretical importance (base frequency) was removed to yield + (1+ Surface frequency |Participant). Surface frequency effects have been well established in several studies, yet base frequency effects remain unclear (e.g., Baayen et al., 2007). If the model still failed to converge after removing all random slopes, random intercepts for items were removed. A potential issue with interpretability here may be an increased likelihood of type 1 error (Barr et al., 2013).

The omnibus model summary is reported in Table 24. The baseline for the fixed effect of surface and base frequency conditions was high base and high surface frequency respectively. Thus, the estimated coefficient (β) for the intercept can be interpreted as average looking time at target items that have both high base frequency and high surface frequency (e.g., leader). The sum of intercept β and surface β reflects average looking time at low surface frequency words. The sum of intercept β and base β reflects average looking time at low base frequency words. The sum of intercept β and interaction β reflects average looking time at low surface and low base frequency words.

Table 24.

Children's Linear Mixed Effects Model Summary for the Fixed Effects Surface and Base, Across Total Time, Go-past, Gaze and First Fixation Durations

	Total time a			Go-past b			Gaze b			First fixation a		
	β	SE	t	***β***	SE	t	***β***	SE	t	***β***	SE	t
Intercept (high surface)	776.90	120.46	6.45	550.44	94.10	5.85	384.35	58.84	6.53	241.21	9.20	26.22
Surface frequency (low)	196.83	144.33	1.31	176.73	102.38	1.73	110.44	60.45	1.83	8.64	9.12	0.95
Base frequency (low)	-13.17	149.37	-0.18	7.07	104.23	0.07	3.36	58.16	0.06	-1.46	9.58	-0.15
Interaction Surface (low): Base (low)	159.03	207.95	0.92	138.05	144.85	0.95	70.01	80.82	0.87	5.00	13.24	0.38

a Surface*base + (1|Participant) + (1|Item)
b Surface*base + (1+surface|Participant) + (1|Item)

Visual inspection of residuals plots suggested fairly normal distribution and homoscedasticity. However, Shapiro-Wilk normality tests on the plot residuals rejected the null hypothesis for normal distribution for all the dependent measures. Also, children's eye-tracking data is often skewed (Breadmore & Carroll, 2018). Thus, the data was log-transformed for the model comparison analysis (see Table 25).

Table 25.

Children's Likelihood Ratio Test Values of Full Models Against Surface Only Models, and Base Only Models Across Total Time, Go-past, Gaze, and First Fixation Durations

Fixed effects	$\chi 2$	df	p
		Surface frequency	
Total time a	6.35	1	0.01
Go-past c	56.69	1	<0.001
Gaze b	8.17	1	0.004
First fixation a	2.13	1	0.14
		Base frequency	
Total time a	0.35	1	0.55
Go past c	7.44	1	0.006
Gaze b	1.17	1	0.28
First fixation a	0.00	1	0.95

a Surface+base + (1|Participant) + (1|Item)
b Surface+base + (1+surface|Participant) + (1|Item)
c Surface+base + (1|Participant)

Likelihood ratio tests comparing the full model to the null interaction models indicated that the interaction between surface and base frequency was not significant for any of the eye movement measures; total time duration, $\chi^2(1) = 0.78$, p =.38 , go-past duration, $\chi^2(1)=3.68$, p=.06, gaze duration $\chi^2(1)=1.40$, p =.24, or first fixation duration $\chi^2(1)=0.36$, p =.55. Although it is worth highlighting that go-past duration was approaching significance (p=.06).

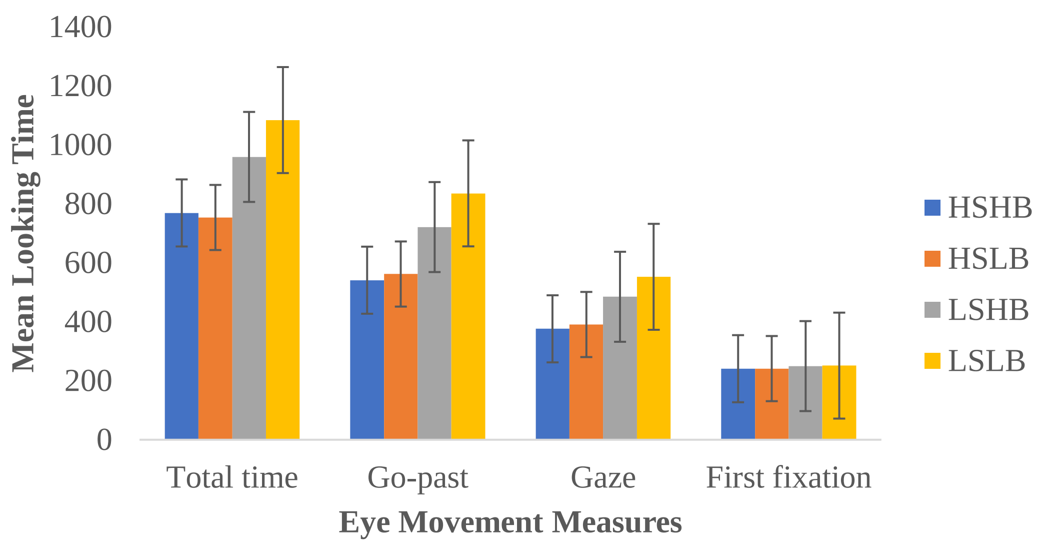
The main effect of surface frequency was not significant in first fixation duration $\chi^2(1) = 2.13$, p = .145, but was significant in all later eye movement measures; total time duration, $\chi^2(1) = 6.35$, $p = .01$, go-past duration, $\chi^2(1) = 56.69$, $p < 0.001$ and gaze duration, $\chi^2(1) = 8.17$, $p = .004$.

The main effect of base frequency was only significant in go-past duration $\chi^2(1) = 7.44$, $p = .006$. The main effect of base frequency was not significant in any other eye movement measure; total time duration, $\chi^2(1) = 0.35$, $p = .55$, gaze duration, $\chi^2(1) = 1.17$, $p = .28$ and first fixation duration, $\chi^2(1) = 0$, $p = .95$.

Figure 6 shows mean looking times across the eye movement measures for each of the word frequency conditions. The pattern of results as reflected in the figure shows that children looked longer at low surface and low base frequency words than low surface and high base frequency words, perhaps suggesting an impact of base frequency on lexical access.

Figure 6.

Children's Mean Looking Times Across the Eye Movement Measures for Each of the Word Frequency Conditions



Note. Mean looking times (ms) are shown across the eye movement measures for each word condition, high surface and high base frequency (HSHB), high surface and low base frequency (HSLB), low surface and high base frequency (LSHB) and low surface and low base frequency (LSLB). Error bars show standard errors.

In order to assess the hypothesis that low base frequency words were fixated significantly more than high base frequency words when overall surface frequency was low, a likelihood ratio test was performed (see Table 26). The results indicated no significant effect of base frequency on all of the eye-movement measures.

Table 26.

Likelihood Ratio Test on Values of Base Only (Low Surface Frequency) Models Against Null Models across Total Time, Go-past, Gaze, and First Fixation Durations

Eye movement measures	$\chi 2$	df	*p*-value
Total time	0.99	1	.32
Go-past	3.02	1	.70
Gaze	1.67	1	.20
First fixation	0.14	1	.71

In summary, in experiment 1, child participants read morphologically complex words which were embedded into sentences. The target words varied on surface and base frequency such that there were for word conditions: High base and surface frequency, high base and low surface frequency, low base and high surface frequency and low base and surface frequency. Four eye-movement measures were recorded (first fixation, gaze, go-past and total time durations) in order to assess the temporal dynamic of morphological processing. Results showed surface frequency effects in children's reading for all the measures except first fixation duration. A base frequency was found for go-past duration, suggesting that decomposition occurs to some degree during children's processing of morphologically complex words but was not mediated by word frequency. The pattern of mean looking times across the four word conditions indicate that children fixate more on low base frequency words than on high base frequency words.

4.4 Experiment 2

For experiment 2, an adult sample was assessed on the same word corpus as was used for the child participants in experiment 1. This provided more evidence as to whether the developmental trend observed is due to ceiling effects (as in Deacon et al., 2011) or an actual difference in the way base word frequency affects word reading as it matures. In experiment 1, significant surface frequency effects were found for gaze, go-past and total time durations. A base frequency effect was found for go-past duration only. Thus, for the following experiment, a pertinent question was whether adults also show similar effects to children on the same stimuli. In exploring this question, we may begin to uncover how reading processes develop from the emerging to the competent reader.

Significant surface frequency effects were expected as has been robustly found in past studies (Joseph et al., 2013; Rayner & Raney, 1996). However, past findings of base frequency effects are certainly mixed. In experiment 1, children did show base frequency effects, perhaps suggesting decomposition of certain words. For this experiment, these effects may not be found due to the usage of the same corpus as was employed for children. This corpus was relatively less complex for adults than it was for the child participants. If adults have access to rich lexical information about the target words, base frequency effects may not be evident. Yet, using the same corpus allows any findings to be directly comparable.

Surface frequency effects have been established in adult readers to a greater extent than has been done for children (Blythe & Joseph, 2011). Rayner and Raney (1996) found surface frequency effects in adults for first fixation duration and gaze duration, although later metrics were not studied. Adults, compared to children, make fewer refixations (Blythe et al., 2011). Thus, surface frequency effects may be evident from very early in the time course of lexical processing. Conversely due to fewer refixations, effects for later eye measures may be attenuated. Thus, surface frequency effects would be evident for adults in the earlier eye movement measures (first fixation duration and gaze duration).

In terms of hypotheses for the time course of base frequency effects (if found), it was unclear which of the four measures examined would yield the greatest effects. If morphological decomposition occurs independently of semantic influence, this perhaps points to a deeper sensitivity to morphological structure than to morpho-semantic information (Frost et al., 2005). Yet for this experiment, morpho-semantic information may likely be more important for word frequency discernment than morphological structure. Traditionally, researchers have argued that morphological form is processed before morphological meaning (Rastle et al., 2000). If this is the case, then it is expected that the later eye-tracking measures would show stronger frequency effects (i.e., go-past and total time durations). However, some have argued that this may not be the case and that analysis of meaning occurs early on (Feldman et al., 2015). In this scenario, it is expected that effects would be stronger for the earlier measures (i.e., first fixation and gaze durations).

4.4.1 Experiment 2 Methodology

4.4.1.1 Participants

Adult participants were staff and students recruited from Coventry University through physical posters. Twenty-three adults were tested. Of these, five were excluded due to educational disabilities (N=1), incomplete data (N=1), and technical issues with the eye-tracker (N=3). Eighteen adult participants remained for analysis (nine male, nine female). Their ages were between eighteen and sixty years and their mean age was 30.61 years (standard deviation=10.07 years). All of the adult participants were either studying for an undergraduate degree or possessed higher qualifications. Adults participants were each given a £5 love2shop voucher for their participation.

4.4.1.2 Materials and Design

Both child and adult participants read the same stimuli, as described in experiment 1 above. Mean performance accuracy on the comprehension questions was above chance at 100% for all four word conditions.

4.4.1.3 Apparatus

Adults used the same apparatus as described in experiment 1.

4.4.1.4 Procedure

Ethical approval was gained from the Health and Life Sciences Research Ethics Committee at Coventry University prior to recruitment and data collection. Participants were given an information sheet and then asked to provide written consent. Following the experiment, participants were debriefed.

Adults were tested in a quiet room at Coventry University. Adults completed the TOWRE-2. Following this they completed the experimental eye-tracker task as described in experiment 1.

4.4.2 Experiment 2 Results and Discussion

4.4.2.1 Data preparation

As in experiment 1, trials were removed upon visual inspection of participants' eye-tracking. In this experiment, seventeen adult trials were removed. Of these, 16 were removed due to the target not being fixated. One was removed because none of the words following the target were fixated. Outliers were not removed for adults.

4.4.2.2 Data analysis

The data was analysed in R (version 3.5.1; R Core Team, 2018) in R Studio (version 1.1.463; PBC, 2018) using linear mixed effects modelling with maximum likelihood using the lme4 package (Bates et al., 2015). Modelling was carried out with maximal random effects structure according to the guidelines reported in Barr et al., (2013). This was carried out using the same method as described in Experiment 1. Table 27 shows the model summary for base and surface frequency across total time, go-past, gaze and first fixation durations.

Table 27.

Adults' Linear Mixed Effects Model Summary for the Fixed Effects Surface and Base, Across Total Time, Go-past, Gaze and First Fixation Durations

	Total time a			Go-past a			Gaze a			First fixation b		
	β	SE	t	***β***	SE	t	***β***	SE	t	***β***	SE	t
Intercept (high surface)	436.42	117.16	3.725	287.28	34.17	8.41	274.825	30.22	9.10	198.53	9.04	21.97
Surface frequency (low)	70.57	108.57	0.65	67.28	38.65	1.74	50.04	32.92	1.52	14.49	10.41	1.39
Base frequency (low)	94.94	108.84	0.87	12.21	38.67	0.32	-5.83	32.95	-0.18	6.33	10.42	0.61
Interaction Surface (low):Base (low)	73.64	153.34	0.48	50.85	54.68	0.93	56.76	46.59	1.22	9.88	14.74	0.67

a Surface*base + (1|Participant) + (1|Item)
b Surface*base + (1+surface|Participant) + (1|Item)

Visual inspection of residuals plots suggests fairly normal distribution and homoscedasticity. However, Shapiro-Wilk normality tests on the plot residuals reject the null hypothesis for normal distribution for all the dependent measures except first fixation duration. Thus, the data was log-transformed for the model comparison analysis (see Table 28).

Table 28.

Adults' Likelihood Ratio Test Values of Full Models Against Surface Only Models, and Base Only Models Across Total Time, Go-past, Gaze, and First Fixation Durations

Fixed effects	$\chi 2$	df	P-value
	Surface frequency		
Total time a	2.73	1	0.10
Go-past b	11.61	1	<0.001
Gaze a	10.21	1	0.001
First fixation a	4.74	1	0.03
	Base frequency		
Total time a	2.35	1	0.13
Go past b	2.63	1	0.10
Gaze a	1.40	1	0.28
First fixation a	2.224	1	0.24

a Surface+base + (1|Participant) + (1|Item)
b Surface+base + (1+surface|Participant) + (1|Item)

Likelihood ratio tests comparing the full model to the null interaction models indicated that the interaction was not significant for any of the eye movement measures; total time duration, $\chi^2(1) = 0.06$, p =.81, go-past duration, $\chi^2(1)$ =0, p=1, gaze duration $\chi^2(1)$ =2.58 , p =.11, or first fixation duration $\chi^2(1)$=0.29, p =.59.

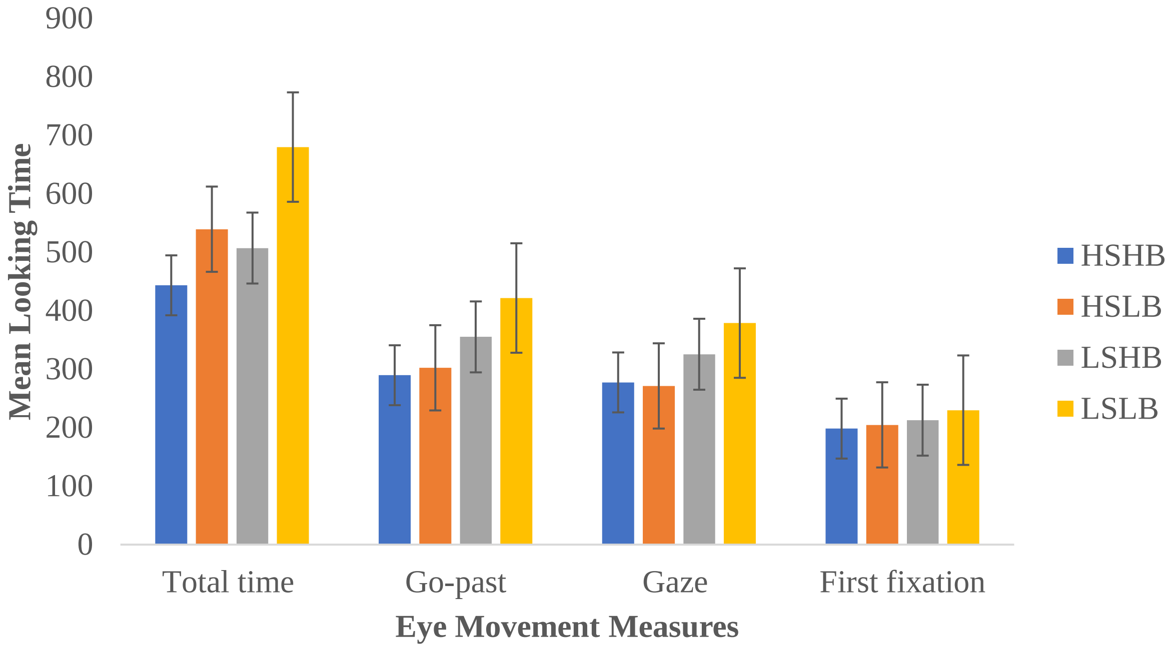
The main effect of surface frequency was not significant in total time duration $\chi^2(1)$ = 2.73, p = .10, but was significant in all earlier eye movement measures; go-past duration, $\chi^2(1)$ = 11.61, p <0.001, gaze duration, $\chi^2(1)$ = 10.21, p = .001 and first fixation duration, $\chi^2(1)$ = 4.74, p = .03.

The main effect of base frequency was not significant in any of the eye movement measures; total time duration, $\chi^2(1)$ = 2.35, p = .13, go-past duration $\chi^2(1)$ =2.63, p = .10, gaze duration, $\chi^2(1)$ = 1.40, p = .28 and first fixation duration, $\chi^2(1)$ =2.22, p = .24.

Figure 7 shows mean looking times across the eye movement measures for each of the word frequency conditions. The pattern of results as reflected in the figure shows that adults looked longer at low surface and low base frequency words than low surface and high base frequency words, perhaps suggesting an impact of base frequency on lexical access. However, this effect was not significant.

Figure 7.

Adults' Mean Looking Times Across the Eye Movement Measures for Each of the Word Frequency Conditions



Note. Mean looking times (ms) are shown across the eye movement measures for each word condition, high surface and high base frequency (HSHB), high surface and low base frequency (HSLB), low surface and high base frequency (LSHB) and low surface and low base frequency (LSLB). Error bars show standard errors.

In order to assess the hypothesis that low base frequency items would be fixated significantly more than high base frequency items when overall surface frequency was low, a likelihood ratio test was performed. The results indicated no significant effect of base frequency on all of the eye-movement measures (see Table 29).

Table 29.

Likelihood Ratio Test on Values of Base Only (Low Surface Frequency) Models Against Null Models Across Total Time, Go-past, Gaze, and First Fixation Durations

Eye movement measures	χ2	df	P-value
Total time	0.91	1	0.34
Go-past	3.02	1	0.70
Gaze	2.78	1	0.10
First fixation	1.60	1	0.21

Experiment 2 extended findings from experiment 1 to examine base and frequency effects on adults. Again, here, surface frequency effects were found. Although this time, they were absent in the latest eye movement measure (total time) and present in the earliest eye-movement measure (first fixation). As expected, base frequency effects were not found for any of the eye-movement measures.

4.5 General Discussion

The aim of the current study was to assess child (experiment 1) and adult (experiment 2) base and surface frequency effects during reading of multimorphemic words in sentences. Children and adults were presented with words from each of four conditions, varying across low surface frequency, high surface frequency, low base frequency and high base frequency. The current study used eye-movement data to employ a more ecologically valid measure. This also enabled investigation of the time-course of word processing. Moreover, data were collected from adults to examine any developmental differences in the reading of morphologically complex words in comparison to children.

In experiment 1, with children, significant surface frequency effects were found for all of the measures except the earliest (first fixation duration). Conversely, in experiment 2 with adults, significant surface frequency effects were found for all the measures except the latest (total time duration). This is in line with past research and is perhaps due to the differences in cognitive abilities between adults and children (Dahan et al., 2001). While adults are able to process the word quickly, children take longer resulting in frequency effects for the later measures. For example, Blythe et al., (2009) found that while children and adults showed similar word length effects for early eye movement measures (e.g., first fixation), children showed stronger effects than adults for later measures (e.g., refixations). Whereas adults were able to process longer words in one fixation, children had to make a short second saccade within the word to successfully analyse it.

In any case, the findings of surface frequency effects for adults are expected and complement the large body of literature which has found the same (Hyönä & Olson, 1995; Albrecht Werner Inhoff & Rayner, 1986; Juhasz et al., 2006; Rayner et al., 1995). For children, there is much less evidence for surface frequency effects. What evidence there is consistently and convincingly demonstrate surface frequency effects in children from as young as seven (Blythe et al., 2009; Joseph et al., 2013; Rayner, Yang, et al., 2013) as well as children with reading difficulties such as dyslexia (Hyönä & Olson, 1995). The current findings for the effect of surface frequency on children's eye movements during reading complements this previous research.

The current study took this investigation a step further to also examine base frequency effects. While surface frequency effects may reflect cognitive processes in word recognition, base frequency effects should reveal even more information about the nature of these processes.

Sensitivity to the features of a word's constituent morphemes suggests morphological decoding of the word (Deacon et al., 2011).

Base frequency effects were not found for adults. Children, contrariwise to adults, showed significant base frequency effects for go-past duration. The lack of base frequency effects found for adults is perhaps indicative of sight word reading via lexical access (Coltheart, 2005). It seems likely that adults were able to access the target words on the basis of their full forms, without the need for morphological decomposition, thereby negating base frequency effects. Thus, base frequency effects were not apparent as the adults already possessed high quality lexical information about the target words (Perfetti, 2007).

The children, meanwhile, appeared to employ morphological decoding to a greater extent to read the words. This finding corroborates models such as the dual-route model, by showing that skilled readers (literate adults) are able to access words using a more automatic lexical process (Coltheart, 2005). Meanwhile intermediate readers might be predicted to use smaller language units in the non-lexical route. The findings from chapter 4 also corroborate Ehri's stages providing evidence for sight-word reading of familiar words from memory during the consolidated phase (i.e., reflected by a lack of base frequency effects for adults). The children, on the other hand, may be in the full alphabetic phase such that they were able to decode unfamiliar words (in this case, using morphemes).

It is important to note that findings from chapter 4 are not in line with other studies such as, for example Taft (2004), which have found base frequency effects in adults. Yet they are in line with at least one other study which has not found base frequency effects (e.g., Bertram et al., 2000). However, Taft (2004) argued that the lack of a base effect does not preclude decomposition but is perhaps indicative of contextual issues such as the type of words examined.

In this study, this certainly appears to the case. The words in this study were designed using frequency data aimed at the child participants. Therefore, the level of text difficulty was higher for the children than for the adults (Blythe et al., 2009). Indeed, previous research has shown that looking patterns are affected by text difficulty (Liversedge et al., 2014). Perhaps, relatively lower overall surface and base frequency words may have yielded base frequency effects in the adults. Indeed Ehri's stages would predict decoding of unfamiliar words, even in the final consolidated phase (Ehri, 2005).

Turning to the time-course of the surface and base frequency effects found for children. In experiment 1, surface frequency effects were observed for the three later eye measures (gaze, go-past and total time durations). Base frequency effects were only observed for the middle of these three measures: Go-past duration. This is surprising, as if decomposition always occurs, then surely any base frequency effects should be apparent earlier than surface frequency effects (Taft, 2004). Yet clearly, base effects arose at the point at which children were able to re-read the beginning of the sentence to re-integrate contextual information (as is reflected by go-past duration). One explanation, as explored by Taft (2004) is that certain words are always decomposed while others are always accessed in their whole form. This would explain why surface frequency effects occur both before and after base frequency effects.

Finally, although, the pattern of direction is as expected, the interaction between surface frequency and base frequency was not significant. Yet, as expected, looking time at low base frequency was higher than at high base frequency words for all participants across all the measures. This finding supports the speculation that some words are always decomposed. My expectation was of robust interaction effects whereby words with low surface frequency would yield significant differences between low and high base frequency words. Yet, if some high surface frequency words also replicated this pattern, perhaps because some words are always decomposed, then the interaction might not be significant. Further research would be necessary to elucidate this matter.

4.5.1 Limitations and Future Directions

One limitation was the construction of suitable sentences for embedding the target items, since this was within very strict parameters. It is possible that some of the sentences contained syntax and grammar that were more plausible than others which might affect looking times. This possibility could not be strictly controlled. Nevertheless, there were eight sentences for each of the four conditions. Multiple sentence frames across conditions should have attenuated the effects from any extraneous variables.

Another limitation was that the stimuli used for both adults and children were targeted at children, as in Deacon et al., (2011). This was done in order to ensure consistency between the two experiments and to allow the two participant groups to be comparable. However, this limited the range of frequencies that could be used as target words, which might have limited the impact of frequency effects for adult participants. In the future, it would be worth replicating this study for adults using a wider range of surface and base frequencies targeted at adults. Also, to examine the time-course of decomposition, it would be insightful to revisit this issue using different types of morphologically complex words and pseudo morphologically complex words.

4.5.2 Conclusions

In conclusion, the present study found evidence for morphological processing during reading through significant base frequency effects for children (experiment 1) but not adults (experiment 2). This finding corroborates models such as the dual-route model (Coltheart, 2005) and Ehri's stages (Ehri, 2005), with a particular emphasis on morphemes. Adults were able to access the target words using sight word reading via the lexical route (reflected by surface frequency effects and a lack of base frequency effects). Conversely, it appears that children accessed words by both sight reading and decomposition into morphemes (reflected by surface and base frequency effects). Whilst foveal morphological processing was examined in chapter 4, in the following chapter, parafoveal morphological processing was examined by investigating how readers access different types of pre-attentive information.

5 Morphological Parafoveal Preview

5.1 Abstract

Results from the previous chapter indexed decomposition processes in children reflected by base frequency effects. Whilst foveal morphological processing was examined in the preceding chapter 4, parafoveal morphological processing was examined in the current chapter 5. In the present chapter, evidence of morphological processing during reading was examined by exploring the effects of different types of parafoveal previews on the processing of morphologically complex words. Specifically, morphological and orthographic previews were compared in children (experiment 1) and adults (experiment 2). The reasons for comparing these different age groups were two-fold. First, examining adults and children allows for the comparison of skilled and intermediate reading strategies. Second, it also provided insight into the developmental progression of multimorphemic word processing. Using the eye-tracker enabled use of the boundary paradigm – with stimuli changing parafoveally while participants read the sentences, as well key analysis of the time-course of effects. Results showed that morphological preview information facilitates word processing for adults and orthographic preview information facilitates word processing for children. From these results, it is inferred that skilled reading takes advantage of particular attention to morphological cues. In terms of the finding of children's morphological processing in the previous chapter and not in this chapter, it is proposed that the type of morphological processing measured in chapter 5 (and found for the adult age group) has not yet developed in intermediate readers.

5.2 Introduction

The study carried out in the previous chapter investigated adults' and children's processing of multimorphemic words in sentences. The current chapter expanded on this by studying differential preview benefits of orthographic and morphological information for multimorphemic word processing. How do these types of information, which are extracted from the parafovea, aid in the understanding of complex words? This type of research exploits the fact that readers generally perceive a target word several characters before directly fixating upon it. Thus, investigating parafoveal preview benefits of different types of words allows insight into the earliest possible processing of multimorphemic words. It will help us to understand to what extent children use morphological information versus orthographic information for lexical access. This might, in turn, offer further information about how lexical units are stored. Moreover, by also assessing adults, we can ascertain how this behaviour develops as well as differences between intermediate readers (experiment 1) and skilled readers (experiment 2).

5.2.1 Morphological priming effects on reading

Morphologically related words share morphemes, but they also share orthographic and semantic features (Beauvillain & Segui, 1992). For example, the morphologically related words *rocker* and *rocking* share the same letter string (orthography) and convey the same meaning (semantics) in their shared root *rock*. A well-established way of assessing the contribution of morphological analysis has been to consider whether the effects of morphological structure can be distinguished from effects of orthographic and/or phonological structure (Amenta & Crepaldi, 2012).

Priming studies have been used widely in research to investigate the role of morphological processing in visual word recognition (Feldman et al., 2009; Lavric et al., 2007;

Longtin & Meunier, 2005). In this paradigm, letter strings (called primes) are presented briefly before given target words. It has been asserted that the presentation of orthographically related (Segui & Grainger, 1990), semantically related (Bajo, 1988) and morphologically related (Feldman & Soltano, 1999) primes have a facilitatory effect (faster and more accurate) on target word processing. Conversely, unrelated primes may have a neutral or inhibitory effect (slower and less accurate) on target word processing. Since morphological relatedness, particularly if transparent, may be confounded with orthographic information, studies have compared different types of primes. Some contain overlapping morphological information; some contain other types of information (e.g. orthographic) and others contain little to no overlapping information (control). Although morphological primes may contain aspects of phonological, orthographic, and semantic information, these may be controlled by comparing primes with other types of cues. These primes are presented for minimal time durations before reading target words so as to avoid conscious encoding yet still elicit subconscious priming facilitation or priming inhibition of the target words.

Specifically, long lag morphological priming is a type of repetition priming in which a morphological variant of the target word is presented as a morphological prime (Rueckl et al., 1997). Initially, word recognition research focused on long lag priming, with longer lag times (i.e. above 300 ms) between stimulus and target presentation (Diependaele et al., 2009; W. Marslen-Wilson et al., 1994). In long lag priming tasks, the prime is made available for long enough to allow its conscious perception. However, claims were made against this due to the view that effects arose from episodic memory traces of the visible prime (Forster & Davis, 1984). Further, facilitatory effects were only observed when prime-target relationships were semantically transparent (Diependaele et al., 2009; Marslen-Wilson et al., 1994). Later research sought to access the early stages of word identification in short lag priming by decreasing the prime duration such that the prime was unconsciously perceived (Feldman & Soltano, 1999).

Originally, research was concerned with highlighting the value of morphemes as linguistic units separable from orthography and semantics (Stolz & Feldman, 1995). Indeed, this was necessary as morphological processing was often minimised to orthographic and phonological patterning (Aronoff, 1976) or as the cumulative effects of form and meaning (Gonnerman et al., 2007). Providing a model for the role of morphological decomposition, Taft's (1988) morphological-decomposition model postulated that multimorphemic words are stored in stem form until a match is made with an incoming letter string, at which point the whole word becomes available. In support of this account of morphological processing, studies found that higher frequency morphologically related primes facilitated multimorphemic word processing (Grainger et al., 1991). Moreover, in support of decomposition, low frequency suffixed words and not high frequency suffixed words yield a priming effect of their stems (Meunier & Segui, 1999).

In a fresh effort to account for a fuller range of linguistic conditions, Marslen-Wilson et al., (1994) used a cross-modal priming task to investigate priming across pairs that were semantically opaque (e.g., casualty-CASUAL), semantically transparent (e.g., punishment-PUNISH), phonologically unrelated (e.g., serenity-SERENE) and phonologically related (e.g., friendly-FRIEND). Their findings suggested that semantic, and not phonological relatedness, was key for morphological decomposition. That is, semantically opaque multimorphemic words such as *apartment/apart* may be stored as unanalysed simple forms whilst transparent forms such as *happiness/happy* are decomposed. A key issue to note, however, is in the cross-modal design of the study. Auditory and not visual stimuli were presented to participants, thus calling into question the study's relevance for visual word processing.

Thus, more recent research deviated from the question of whether morphemes are credible linguistic units, as a preponderance of evidence suggests that they are (summarised in Feldman, 2013). The more recent debate has centered around whether morphologically complex words are decomposed based on semantic relationship or whether an automatic process of decomposition occurs based on morpho-orthographic analysis (Rastle & Davis, 2008). The latter has found effects from morphological structure, independent of semantic information (Paterson et al., 2011). Pseudo-related pairs (e.g., corner-CORN) yield higher facilitation than do form-related pairs (brothel-BROTH), and similar facilitation to morphologically related pairs (e.g., cleaner-CLEAN) (Rastle et al., 2004). Moreover, Rastle et al., (2000) showed that prime-target pairings with a transparent morphological relationship produced priming effects whilst sematic only pairings showed effects only for longer prime durations.

The effect of morphological structure appears to be impervious to variations in phonology. Tang and Witzel (2020) found similar priming for morphologically related word pairings which shared phonological information (e.g., healer-HEAL) as well as those which did not (e.g., health-HEAL). This finding is in line with the Morphological Pathways Framework which maintains a separate and unique route from morphological awareness in the linguistic system to lexical representations via morphological analysis (Levesque et al., 2020).

A key consideration in studying morphological processing are the developmental ramifications. If morphological form is instrumental in effective identification of morphologically complex words, then this finding is surely informative for literacy instruction. Several studies have shown that children access morphological form in priming studies in French (e.g., Beyersmann et al., 2015; Quémart et al., 2011) and German (e.g., Hasenäcker et al., 2016, 2020; Jacob et al., 2019). Casalis et al., (2009) primed French fourth grade children's reading of morphologically complex target words with a morphologically related word, an orthographically related word and an unrelated word. While both orthographic and morphological conditions facilitated word recognition at a prime duration of 75 ms, the morphological condition evidenced significantly greater facilitation of response latencies at 250 ms. The authors suggest that this pattern of results indicate a morphological activation point where in children are able to use morphological information for word recognition. The study highlights how children may use morphological analysis in addition to information at smaller grain sizes (e.g., phonemes) in order to decode words.

In English-speaking children, the evidence for morpho-orthographic decomposition is less clear than it is for adults (Casalis et al., 2015). Beyersmann et al., (2012) found that while adults were primed by both pseudo- and real suffixed primes, year 3 (7-8 years old) and year 5 (9-10 years old) children were only primed by true morphological relationship. This finding may indicate that earlier in development, the added semantic component of the truly suffixed primes aid in lexical access but not morphological structure per se. Adding to this evidence, McCutchen et al., (2009) used a continuous lexical decision task (where both the prime and target require responses) to investigate the differences in priming effects of orthographic, semantic and morphological information in fifth grade students (10 years, 11 months) and eight grade students (13 years, 10 months). The results showed stronger priming effects for morphological structure than orthographic and semantic information for all ages, providing evidence for children's sensitivity to morphological structure. Moreover, the authors argued that although the experiment was still contrived, it was a step closer to normal reading than brief-duration priming tasks. However, crucially, naturalistic reading of morphologically complex words occurs within sentences.

Yet, Quémart et al., (2018) found more balanced roles for semantic relatedness and form relatedness in a lexical decision task carried out with grade 3 children (mean age=8;11) and grade 5 children (mean age=10;11). The authors argued that priming effects could not be attributed exclusively to either form or sematic relatedness during morphological processing. Priming effects were larger for morphologically related prime-target pairs with high semantic (e.g. *boldly-bold*), than for morphologically related prime-target pairs with moderate semantic pairings (e.g., *lately-late*), which in turn showed larger priming effects than did morphologically related prime-target paris with low sematic relatedness (e.g., *belly-bell*). This pattern emerged despite all of these conditions containing similar levels of form overlap. Yet, semantic relatedness alone was not responsible for these results. The morphologically related prime-target pairs with high semantic relatedness showed higher priming effects than the semantic only condition despite the higher semantic rating for the semantic only condition. One possibility for discrepancies may be related to the different ages studied. Perhaps older children and adults who are more skilled readers have a higher sensitivity to morphological structure. This has been suggested elsewhere, and argued to in turn help them to decode unfamiliar words (Nagy et al., 2000).

Providing clarification using a visual lexical-decision task, Dawson et al., (2018) was the first study to examine morphological processing in adults, older adolescents (16-17 years old), younger adolescents (12-13 years old) and children (7-9 years old). Participants were presented with pseudomorphemic nonwords containing a real stem and suffix (e.g., *earist*) and control nonwords containing a real stem and nonmorphological ending (e.g., *earilt*). All age groups were more likely to incorrectly accept pseudomorphemic nonwords than controls, with stronger effects for the older adolescents and adults. However, while older adolescents and adults were slower to reject the pseudomorphemic nonwords than controls, this effect was not found for younger adolescents and children. The authors concluded that the differences found may reflect automatized tacit morphological knowledge in the older age groups that has not yet developed in the younger age groups. One possible mechanism suggested for the differences in findings was in the semantic interpretability of the pseudomorphemic nonwords compared to the control nonwords. Reliance on more explicit morphological knowledge provided by sematic information within the morphemes may have been reflected in accuracy effects and not reaction time effects. However, the authors conceded that the lexical decision task used precludes more direct exploration of form-based and meaning-based decomposition.

Indeed, there are flaws within the traditional lexical decision paradigms which restrict their generalisability. Traditional paradigms have provided a wealth of invaluable evidence about morphological processing, and this knowledge has served to advance understanding about the topic. Some recent studies have instead opted to use the eye-tracker to assess sensitivity to morphological structure (e.g., Paterson et al., 2011). However, those studies have focused on visual word recognition. Outside of experimental environments, morphological processing occurs during natural reading of morphologically complex words within the context of sentences. Visual word recognition is only one component of that process. For several reasons, morphological processing may be sensitive to experimental procedures. Target words should be embedded within sentences as opposed to in isolation. This may be particularly important for morphology with its links to syntactic, semantic and orthographic cues (Carlisle, 2000). To a greater extent than other language devices, morphology combines several other linguistic components. Morphological structure is governed by grammatical rules, intrinsic semantic meaning within each morpheme and largely intact linguistic representation.

5.2.2 Parafoveal Analysis

A pertinent point to consider then is how we can examine the effects of morphological primes, as in lexical decision tasks, but within more natural sentence reading. The boundary paradigm using the eye-tracker solves the issues presented in the paragraph above. In the section that follows, an overview is provided about the use of the perceptual span in eye-tracking paradigms before returning to discussion about morphological processing, this time with the boundary paradigm.

5.2.2.1 Perceptual span

Thus more recently, research has used eye-tracking paradigms to explore morphological processing (Bertram, 2011). Of interest to those investigating reading using eye movements is the perceptual span. The perceptual span refers to the number of characters that a reader can perceive during fixation and is generally four characters to the left and 15 characters to the right (Rayner, 1986). Perceptual span is an important marker for cognitive development in that much of the information regarding an upcoming word is gleaned parafoveally (Blythe, 2014). It follows then that effective reading takes advantage of a larger perceptual span, enabling the mature reader to pre-process characters before fixation. The perceptual span can be examined through experimental manipulations that influence foveal (relating to the fixated word) and parafoveal processes (processing of words to the right of the fixation) (Schotter et al., 2012). Such studies show that adults pre-process several words to the right as they read (Rayner, 1998).

Rayner (1986) was one of the first studies to investigate the development of the perceptual span. Eight-year-olds had a smaller perceptual span to the right (approximately 11-

character spaces) than did 10- and 12-year-olds (approximately 14-15-character spaces). Ten- and twelve-year olds did not differ from adults if the text was kept age appropriate. Significant technological advances mean that eye-trackers today are more precise, reliable, sensitive, and less invasive than those used in the 1980s and 1990s. Nevertheless, a more recent study by Häikiö et al., (2009), using the Eyelink 1000 eyetracker, replicated these results and even extended them to Finnish, thus supporting their stability across technologies, languages and decades. In this study using the moving window paradigm to investigate identification of characters to the right of a single fixated word, 8-year-olds identified 5 characters, 10-year-olds identified 7 characters, and 12-year-olds and adults identified 9 characters. In the moving window technique, participants read text within an experimenter-defined window which moves synchronously with their eyes (McConkie & Rayner, 1975).

Importantly, Sperlich et al., (2016) replicated these cross-sectional findings in a longitudinal design. Of note, they found that the change in perceptual span was only significant between Grade 2 (mean age 8.00 years) and Grade 3 (mean age 9.02 years) and not between Grades 3 and 4 (mean age 10.03 years), perhaps highlighting this as a stage of strong growth in perceptual span. The investigators concluded that the lack of effect found between Grades 3 and 4 may be due to testing at a coarser grain size (1-year vs 2-year increments) than previous studies (Häikiö et al., 2009; Rayner, 1986).

5.2.2.2 Boundary paradigm: Adults

These characteristics of the perceptual span are used in boundary paradigm studies to examine parafoveal effects of various language components using eye-tracking technology. The boundary paradigm enables us to design a study that tests whether what is known about visual word recognition in single words is applicable to sentence processing by altering the information presented to participants parafoveally.

The eye-tracker is able to track the movement of participants' eyes in real-time and uses that information to alter the information that is displayed parafoveally. An invisible boundary is placed to the left of the target word. While the eyes are still to the left of the target, it is replaced with a different word which may share varying levels of overlapping information with the target. For example, the word 'rocked' may be used a preview for the target word 'rocker', both of which share a common root 'rock'. Once the eyes cross this invisible boundary, the word imperceptibly changes to the target word. This change is not consciously perceived by the reader because it occurs during a saccade from the previous word to the target which triggers saccadic suppression. Thus, the preview word can only be gleaned parafoveally. Different conditions can be implemented by changing the preview word across trials. Preview benefits may be achieved if the preview condition serves to decrease looking at the target, thereby decreasing cognitive load required for processing. The boundary paradigm has shown parafoveal preview benefits for a range of linguistic concepts including word class validity and syntactic constraints (Brothers & Traxler, 2016), orthography (Bélanger et al., 2013), and phonology (Miellet & Sparrow, 2004).

General understanding of the mechanism underlying preview benefits suggest that words included in the preview are pre-activated while in the parafovea followed by integration with the target information. This account might be relevant for orthographic information, whereby pre-activation of overlapping form would prime the target (Snell et al., 2017). In this scenario, preview benefit is based solely on the orthographic relatedness between the preview and the target. Angele et al., (2013) examined the effects of repeated word (e.g., *news-news*), semantically related (e.g., *news-tale*) and orthographically related (e.g., *news-niws*) preview benefits. Repeated word and orthographically related preview benefits provided similar faciliatory effects while semantically related preview benefits provided none. It was argued that shared letters facilitated processing of the foveal word. Conversely, different letters competed with the target and slowed down processing.

However, there is consensus that parafoveal processing is influenced by other features beyond orthographic form. Phonology is one such feature. For example, Miellet and Sparrow (2004) found that fixation durations were shorter for parafoveal previews of the correct word than spelling control pseudowords in French (e.g., *chaise-choise*) . On the other hand, there was no significant difference between correct word previews and pseudohomophone previews (e.g., *chaise-cheise*). Phonological priming seems to occur due to extraction of phonological codes from orthographic stimuli. Similarly, researchers have found no significant differences between the faciliatory effects of preview words when the case is changed (e.g., *up-UP*), suggesting effects above and beyond simple overlapping visual information (Rayner et al., 1980).

Regarding the priming effects of higher-order information such as semantics, results have differed (Snell et al., 2017). This seems expected given the deeper level of processing necessary for semantic information compared to orthographic or even phonological information. Orthographic form is generally identified before being mapped onto semantics (Grainger & Ziegler, 2011). Whilst Inhoff et al., (2000) found parafoveal facilitation effects for semantically related previews, Angele et al., (2013) only found effects for orthographically related previews. Indeed, there was a key difference in the materials used in both studies. Inhoff et al., (2000) employed preview-target pairings with significant orthographic overlaps (e.g., *mother-father*). Conversely, Angele et al., (2013) had much less orthographic overlap in their materials (e.g., *news-tale*). This difference might encourage one to conclude that semantic previews provide no faciliatory effects and that any effects found are due to orthographic similarities instead. Yet, Schotter (2013) found such facilitation effects for semantic relatedness. Specifically, effects were found for synonymous preview- target pairings (e.g., *rollers-curlers*) but were not found for related preview-target pairings (e.g., *styling-curlers*). Thus, a key caveat in examining sematic preview benefits is the relative similarity between the preview and the target.

Taken together then, there is evidence for extraction of both semantic and orthographic information. A key question is whether morphological relatedness, which combines both semantic and orthographic similarities, might provide more facilitation. For example, consider the words *rocked* and *rocker.* These words have orthographic and semantic overlap due to their shared stem. Yet, despite this, and although morphological parafoveal preview benefit effects have been found in languages such as Hebrew (Deutsch & Meir, 2011), Russian (Stoops & Christianson, 2019) and Malay (Winskel, & Salehuddin 2014), no study has examined morphological previews in English suffixed words.

Some studies have examined parafoveal processing within compound words (instead of to the right of the fixated word). Hyönä et al., (2004), for example, examined the processing of morphologically complex words in Finnish. In the control condition, there was no display change. In the experimental condition, all but the first two letters of the second constituent were changed to visually similar letters until the boundary was crossed. They found that fixation on the word following the target was significantly longer in the display change condition. This finding suggests that readers were able to process the later letters of the second constituent. Crucially, however, this study was carried out in Finnish which is dense in morphologically complex words compared to English (Moscoso del Prado Martín et al., 2004). It is possible that, compared to English readers, Finnish readers are highly adept at processing morphologically complex words.

Therefore to examine the issue In English, Juhasz et al., (2009) found a larger effect of parafoveal preview on unspaced than spaced compound words (e.g., *basketball*, *tennis ball*), between correct or partial parafoveal preview (e.g., *ball* or *badk*). This perhaps suggests that readers are more likely to treat the unspaced compound as a linguistic unit. Moreover, processing of this linguistic unit appears to occur sequentially and not in parallel. For example, Drieghe et al., (2010) examined boundary change manipulations of monomorphemic words (e.g., *fountaom* as a preview for *fountain*) and compound words (e.g., *bathroan* as a preview for *bathroom*). The preview yielded no effects on the fixation time of the first constituent of the compound word but did on corresponding letters of the monomorphemic word. This provides evidence, then, that readers access individual morphemes within multimorphemic words. Yet, clearly, effects found in compound words may not be applicable to suffixed words. Moreover, it would be difficult to examine parafoveal processing within suffixed and prefixed words due to the generally short length of English prefixes and suffixes (Bertram, 2011).

Thus, suffixed words would likely need to be presented separately from the morphologically complex word instead of including the boundary (/) within the word (e.g., *rocked / rocker* as opposed *to rock / er).* Morphologically related suffixed words contain the same root (e.g., *rock*) but different affixes (e.g., *rocked-rocker*). This is a key point because several researchers contend that the reader can only encode the final 2-3 letters visually, whereas the first few letters may be encoded orthographically (Bertram, 2011). In other words, the final few letters may only be accessed as coarse visual shapes. If this is true, then there should be no differences in the parafoveal processing for morphologically related previews (e.g., *rocked-rocker*) as for orthographically related previews (e.g., *rocked-rocket*).

No studies have carried this out using suffixed words. Assessing morphological previews presented to the left of English prefixed words, Kambe (2004) investigated preview effects for pseudoprefixed words (e.g., region), bound-stem prefixed words (e.g., reduce) and free-stem prefixed words (e.g., review). Four preview conditions were used for each word: identical preview (e.g., reduce), prefix only (e.g., rehsxc), stem only (e.g., zvduce), and control (e.g., zvhsxc). No evidence was found for the facilitation of early word processing from morphological constituents. Further, although all conditions resulted in word facilitation, the identical condition provided the greatest preview benefit. However, importantly, only prefixed words, and not suffixed words, were examined. Indeed Colé et al., (1989) found that cumulative root frequency determined the latencies to suffixed words but not prefixed words. These results suggest that whilst suffixed words are accessed by the root, and thus decomposed, prefixed words are not. Therefore, the absence of preview benefit for prefixed words cannot be assumed to extend to an absence in suffixed words. Moreover, to date no study has examined the developmental progression of morphological priming using the boundary paradigm.

5.2.2.3 Boundary paradigm: Children

There has been a dearth of studies using the boundary paradigm to examine English morphological processing in children. As discussed above, the few studies that have examined the parafoveal preview benefits of morphological structure have done so with adults, reading compound words, finding facilitatory effects in other languages such as Russian (Stoops & Christianson, 2019) Finnish (Hyönä et al., 2004), Hebrew (Deutsch & Meir, 2011), and German (Mousikou & Schroeder, 2019).

Importantly, studies have found that children as young as eight are able to pre-process whole words in the parafovea (Milledge et al., 2020). Moreover, as found in Chapter 4, effects of linguistic processing are generally observed during later eye-movement measures for children than for adults. What is unknown though, is the extent to which children are able to parafoveally process linguistic information. That is, are children able to process coarse visual form, orthographic and phonological codes, semantic or morphological information?

Marx et al., (2016) found that German-speaking children in Grade 2 (age: 8 years 5 months), Grade 4 (age: 10 years 4 months) and Grade 6 (age: 12 years 6 months) all showed evidence of parafoveal processing. However, the magnitude of preview benefit increased with reading fluency, and phonological decoding skill. Moreover, even the most experienced readers rarely processed words with a single fixation (<30%), indicating grapheme-phoneme decoding. With the focus on phonological decoding in primary years, it seems natural that parafoveal processing would increase with phonological skill. Emphasising this point, Tiffin-Richards and Schroeder (2015) found that German-speaking children extracted phonological information in the parafovea while German-speaking adults extracted orthographic information. These results suggest that phonological information is relied upon during children's reading and that orthographic information becomes increasingly important with reading skill development. Given that children encounter more morphologically complex words as their reading skill develops (Carlisle, 2003), it would be intuitive to examine the extraction of morphological information in the parafovea. Yet, to my knowledge, no studies have investigated the developmental trend of morphological pre-processing in the parafovea in English.

However, there is some evidence that children are able to pre-process morphological information in Finnish. Häikiö et al., (2010) found that Finnish-speaking eight-, ten- and twelve-year-old children extracted more parafoveal information from the second constituent in a compound word (e.g., *kummitustarina* “ghost story”) than from the same word when it was a noun in an adjective-noun phrase (e.g., *lennokas tarina* “vivid story”). Yet, there are three key reasons that this may not be generalisable to the parafoveal extraction of morphological information in English-speaking children. Firstly, the study was carried out in Finnish which is distinctly different to English in its morphological representation. As English contains significantly fewer morphologically complex words, it may be argued that Finnish-speaking children should be more sensitive to morphological features. Secondly, compound words are different from inflected morphologically complex words, lacking morphological inflection between the constituents. Finally, one might argue that it is unclear to what extent the effect observed is due to spatial differences between the constituents in the compound word and the adjective-noun phrase. Whereas the adjective-noun phrase possesses a physical space between the constituents, the compound word does not. Thus, crucially, there remains a lack of evidence as to whether English-speaking children parafoveally extract morphological information, particularly in naturalistic reading of sentences.

5.2.3 The present study

The current study applied the eye-tracking boundary paradigm to assess the priming effects of morphological and orthographic information in natural reading. The paradigm may be akin to lexical-decision tasks but incurs more natural reading in sentence context. Moreover, eye-tracking enables us to collect data about the time-course of word processing, which may be another way to explore and index these different aspects of morphology (Amenta et al., 2015; Cécile Beauvillain, 1996). For example, the semantic aspect of morphology which takes longer to access than the initial form aspect, may be indexed by later eye-tracking measures such as total time duration. Finally, the experimental procedure does not require any effortful action from the participant apart from reading. This ensures that experimental interference is minimal. Again, this is of particular relevance to morphological processing which has been described as an implicit skill; one that that the reader uses without conscious effort (Deacon et al., 2008). In the study that follows, the parafoveal processing of orthographic and morphological information was examined in children (experiment 1) and adults (experiment 2).

5.3 Experiment 1

The aim of the current experiment was to examine the effects of morphologically and orthographically related previews in the parafovea on children's processing of complex words. It was expected that there would be preview benefits for both the orthographically related and morphologically related previews. That is, compared to controls, morphologically and orthographically related previews would yield shorter looking times at the target complex words. Since lexical decision tasks (e.g., McCutchen et al., 2009) have found evidence for increased morphological priming, we expected that there would be a greater preview benefit for the morphologically related previews than the orthographically related previews. Finally, regarding the time course of these effects, it was expected that children would yield stronger effects for the earlier eye-movement measures (i.e., first fixation and gaze durations) than the later eye-movement measures (i.e., go-past and total time durations) as found in previous studies (e.g., Milledge et al., 2020).

5.3.1 Experiment 1 Methodology

5.3.1.1 Participants

Participants and apparatus were identical to experiment 1 of Chapter 4. Indeed, the sentences for the current experiment served as filler items for Experiment 1 of Chapter 4 (and vice versa) and were presented intermixed with one another. For ease, this is repeated here. The child participants were tested at a free Science event for families held at Coventry University. Participants were invited to the event by social media, posters and through e-mails to teachers and parents from the research group's database. Parents completed consent forms for their children's participation. Children were also asked if they wanted to participant and provided verbal assent. Thirty-eight children took part in the experiment. Of these, thirteen participants were excluded due to non-completion of the task (N=5), parent reported educational disabilities (N=4) and atypically poor reading (standardised TOWRE scores below ninety, N=4). Twenty-five participants remained for analysis (10 male, 15 female). Twenty-four participants completed the task and one completed 20 of the 32 items. Their ages were between seven and twelve years, and their mean age was 10 years, 2 months (standard deviation=18.67 months). There were seven 7-year-olds, four 8-year-olds, six 9-year-olds, three 10-year-olds, four 11-year-olds and one 12-year-old. According to parental reports, all participants had normal or corrected-to-normal vision and no known hearing, reading or developmental difficulties. To ensure that participants did not have any reading difficulties, they were pre-screened with the Test of Word Reading Efficiency - Second Edition (TOWRE-2; Torgesen et al., 2012). This confirmed that participants had the age-appropriate levels of word and nonword reading ability (TOWRE: mean standardised score 108.33, sd 9.27, range 95-129). Ethical approval was gained from the Health and Life Sciences Research Ethics Commitee at Coventry University prior to recruitment and data collection.

For the current study, the boundary paradigm technique (McConkie & Rayner, 1975) was employed, and the display changes occurred within 10 ms of the eye crossing the boundary (programme adapted from Pagán et al., 2016). Stimuli and trial procedure differed and are described below.

5.3.1.2 Materials and Design

Preview words. Thirty experimental sentences were constructed for the task. Additionally, thirty-two filler sentences with no display change were presented (see Experiment 1 in Chapter 4). The experiment used a one factor within-subjects design, and all the participants viewed all three preview conditions for each item (morphological, orthographic and control). The dependent variables measured were fixation duration, number of re-fixations, and number of fixations.

Each sentence contained a target word of 5-7 letters. For each target word (e.g., *marker*), there were three preview conditions: a morphologically related word (e.g., marked), an orthographically related word (e.g., *market*) and a control (e.g., *markol*). Each of these conditions served as parafoveal previews for the target word. In the morphologically related word condition, words were morphologically related to the target word and shared the same base. In the orthographically related word condition, words contained the target root but was not morphologically related to the target word. The control condition was a non-word which contained the target root with a suffix made up of letters which resembled the suffix from the morphologically related condition. Therefore, it contained the same number of letters and visually similar letters were chosen. For example, ascenders were replaced with similar ascenders, descenders were replaced with similar descenders, and round letters were replaced with similarly round letters (see Appendix F for the item list). The properties of the words in the preview conditions were carefully matched (see Table 30 for a summary).

Table 30.

Word Length, Number of Syllables, CELEX Frequency, Bigram Frequency and CBBC Frequency for the Target Word and each of the Three Preview Conditions (Morphological, Orthographic and Control). Standard Deviations in Parentheses

Preview condition	Number of letters Mean (*SD*) Range	Number of syllables Mean (*SD*) Range	CELEX frequency Mean (*SD*) Range	Bigram frequency Mean (*SD*) Range	CBBC frequency Mean (SD) Range
Target	6.5	1.9	97.6	173.8	4.2
	(0.7)	(0.3)	(268.7)	(113.5)	(0.9)
	5-7	1-2	2.2-861.5	40.8-299.7	3-5.8
Morphological	6.3	1.4	301.5	201.8	4.2
	(1.1)	(0.5)	(862)	(78.9)	(0.9)
	4-8	1-2	1.1-2750.8	29.3-305	2.9-6.2
Orthographic	6.3	2	38.2	77	4
	(1.1)	(0.6)	(56.3)	(33.1)	(0.8)
	4-8	1-3	0.8-148.8	27-137.6	2.7-5.1
Control	6.3	2	N/A	39.4	N/A
	(1.1)	(0)		(16)	
	4-8	2		10-61.8	

Independent samples t-tests confirmed that CELEX written word frequencies did not differ significantly across the target, the morphologically related condition and the orthographically related condition ($t<1$). Across the three conditions, the number of letters and syllables were all similar ($t<1$). See Table 31 for a summary.

Table 31.

P- and T- Values from T-tests for Length, Number of Syllables, CELEX Frequency and Bigram Frequency Across the Target and each of the Three Preview Conditions

Comparisons	Number of letters t-value, p-value	Number of syllables t-value, p-value	CELEX frequency t-value, p-value	Bigram frequency t-value, p-value	CBBC frequency t-value, p-value
Target vs Morphological	t(18)=0.50, p=0.63	t(18)=2.61, p=0.02	t(18)=-0.71, p=0.48	t(18)=-0.64, p=0.53	t(18)=-0.10, p=0.99
Target vs Orthographic	t(18)=0.50, p=0.63	t(18)=-0.56), p=0.58	t(18)=0.68, p=0.50	t(18)=2.59, p=0.03	t(18)=0.37, p=0.71
Morphological vs Orthographic	t(18)=0,p=1	t(17.85)=-2.71, p=0.01	t(18)=0.96, p=0.36	t(18)=4.61, p=0	t(18)=0.37, p=0.72
Control vs Target	t(18)=0.50, p=0.63	t(18)=-1.00, p=0.34	N/A	t(18)=3.70, p=0.005	N/A
Control vs Morphological	t(18)=0, p=1	t(18)=-3.67, p=0.005	N/A	t(18)=6.38, p=0	N/A
Control vs Orthographic	t(18)=0, p=1	t(18)=0, p=1	N/A	t(18)=3.23, p=0.005	N/A

Design: Sentences. For each target word, three sentences were created for the three preview conditions such that the sentence frame was identical up to word N+1 (see Figure 8).

Figure 8.

Example of Boundary Changes Viewed for the Three Preview Conditions Using The Target Word Item 'Marker'

Preview condition	Before boundary change	After boundary change
Morphological	Tom used a | marked to draw a picture.	Tom used a | marker to draw a picture.
Orthographic	Tom used a | market to write his name.	Tom used a | marker to write his name.
Control	Tom used a | markol to make the card.	Tom used a | marker to make the card.

Target word: marker

|: the location of the boundary. *: the position of the eye. Each of the preview condition words were embedded into all three of the sentence frames across the three participant lists.

The target word, N, was always the fourth word and all sentences were composed of eight words in total. Three stimulus lists were created so that across participants each preview condition word was counterbalanced into each of the three sentence frames. Participants were each presented with one of the three lists. This was done to prevent any biases from the differences in sentence frames across the conditions. Experimental sentences were presented in random order. Comprehension questions were administered after half of the sentences to ensure that participant read for meaning.

5.3.1.3 Apparatus

Eye movements were recorded, and sentences were presented using ExperimentBuilder (version 2.1) on a 24-inch monitor at a viewing distance of 70 cm, with a refresh rate of 144 Hz and resolution of 1,024 by 768 pixels. Reading was binocular; however, eye movements were recorded from only the right eye using an Eyelink 1000+. Participants were asked to place their heads in a chin/forehead rest to reduce movement. Sentences were presented in black, Courier New, size 12 font on a grey background in the middle of the screen; three characters subtended 1° of visual angle. A three-point calibration was used and repeated after every trial.

5.3.1.4 Procedure

In a separate testing session on the same day participants completed three background measures, namely the TOWRE-2, British Picture Vocabulary Scale 3 (BPVS3; Dunn et al., 2009), and Raven's Progressive Matrices (Raven, 1958). Participants also took part in other research experiments and non-experimental activities on the same day.

To complete the current experimental task, participants were asked to sit in a quiet room on a chair and a booster seat as necessary. A chin/forehead rest was used to minimise head movements. Participants were instructed to read each sentence silently and informed that comprehension questions would follow some sentences. A cross appeared on the screen directly before the presentation of each sentence. This was done to ensure that participants always fixated at the same position before reading each sentence. Immediately after reading each sentence, participants were asked to look to the bottom right corner of the screen which prompted the experimenter to press a key on the keyboard to progress to the next sentence. For every other sentence, participants were presented with a comprehension question to which they verbally responded Yes/No to progress. Each of the comprehension questions corresponded to the last sentence read and the participants could not review the sentence to assist with answering. Each sentence and comprehension question were presented one at a time in the middle of the screen. Participants completed drift correction after every sentence and the experimenter recalibrated as necessary. Participants were given a 3-minute break after reading half of the sentences. They were informed that they could take additional breaks as desired and that they were free to withdraw at any time. The eye movement experiment lasted approximately 25 minutes.

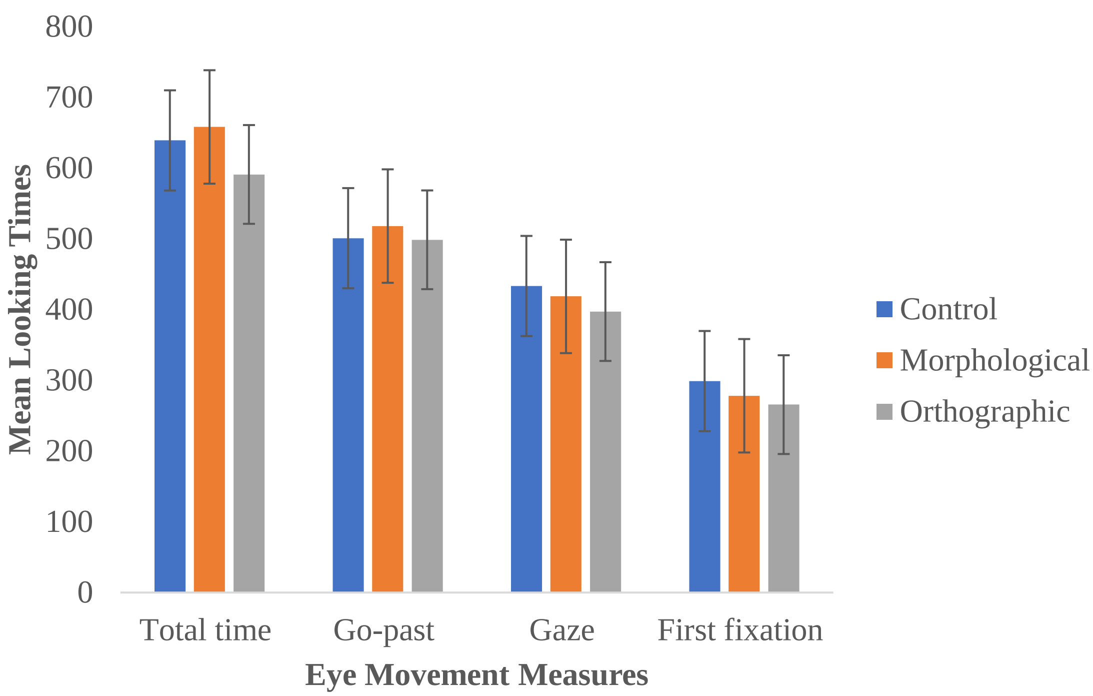
5.3.2 Experiment 1 Results and Discussion

Children scored 136/191 (71.2%) for the comprehension questions. The "clean" function in Data Viewer was used during data extraction as described in Chapter 4. For this experiment, items were also removed when the target wasn't fixated on the first pass, the boundary change occurred on words preceding the target, and the boundary change occurred more than 15 ms after the onset of the first fixation on target. This process resulted in 543/743 (73.08%) remaining items for analysis. Total time (the sum of all fixations on the word), go-past (the sum of all first-pass fixations until leaving the word to the right), gaze (the sum of all first-pass fixations until leaving the word) and first fixation duration measures were log transformed for analysis (Breadmore & Carroll, 2018; Pagán et al., 2016).

Figure 9 shows the mean looking times at the target morphologically complex words following morphological, orthographic and control parafoveal previews. Across all the eye movement measures, looking times were lowest in the orthographic condition indicating that the orthographic preview yielded the most benefit for target word processing.

Figure 9.

Children's Mean Looking Times (ms) at the Target Morphologically Complex Words Following Control (Unrelated), Morphologically Related and Orthographically Related Previews across Total Time, Go-past, Gaze and First Fixation Durations



Note. Error bars show standard errors.

Analyses were carried out using linear mixed effects modelling, following the same procedures outlined in experiment 1 in Chapter 4. Full models included random intercepts for participants and items. The control words formed the baseline for the fixed factor of word type (control, orthographic, morphological). Regardless of the significance of the omnibus analyses, a priori comparisons were conducted between (a) control and orthographic conditions, (b) control and morphological conditions and (c) orthographic and morphological conditions. These contrasts are both theoretically and statistically justified (Schad et al., 2020). They are necessary to test the hypotheses and, moreover, including all three word type conditions in a single analysis limits variance and introduces overlap between groups (for example, the orthographic and morphological words were matched for word length and shared the same first few letters). LME summary statistics for the omnibus analyses are presented in Table 32.

Table 32.

Omnibus Children Linear Mixed Effects Summary for Control, Morphological and Orthographic Word Types

	First fixation [b]			Gaze [a]			Go-past [a]			Total duration		
Fixed effects	β	SE	t	β	SE	t	β	SE	t	β	SE	t
Intercept: Control word	298.15	15.04	19.82	433.65	48.76	8.89	505.19	61.34	8.24	648.77	75.12	8.64
Orthographic word type	-31.09	12.57	-2.47	-39.18	35.45	-1.11	-11.72	47.38	-0.25	-45.28	66.03	-0.69
Morphological word type	-23.15	12.75	-1.82	-25.81	35.83	-0.72	4.33	47.54	0.09	0.90	65.84	0.01

[a]Word type+ (1|Participant) + (1|Item).
[b] Word type + (1|Participant)

Omnibus analyses for main effect of word type (control, orthographic, morphological) revealed a significant effect in first fixation duration, $\chi2(2)=5.97$, $p=0.04$. However, in total time duration, $\chi2(2)=1.43$, $p=0.49$, go-past duration, $\chi2(2)=2.22$, $p=0.33$, and gaze duration, $\chi2(2)=4.18$, $p=0.12$, the omnibus analysis for main effect of type was not significant. For first fixation duration, the orthographic word type yielded the shortest looking time, followed by the morphological word type and the control word type. To understand which conditions differed significantly, a priori analyses compared each pair of conditions.

When comparing the control word type with morphological word type only, there were no significant main effects of type for any of the measures: Total time duration, $\chi2(1)=0.40$, p=0.53, go-past duration, $\chi 2(1)=2.25$, p=0.13, gaze duration, $\chi 2(1)=1.99$, p=0.16, and first fixation duration, $\chi 2(1)=2.18$, p=0.14.

When comparing the control word type with orthographic word type only, there were significant main effects of type for the earlier measures: First fixation duration, $\chi 2(1)=5.46$, p=0.02 and gaze duration, $\chi 2(1)=4.67$, p=0.03. However, no significant effect of type was found for the later measures: go-past duration, $\chi 2$ (1)=1.29, p=0.26, and total time duration, $\chi 2$ (1)=1.84, p=0.17.

When comparing the morphological word type with orthographic word type only, there were no significant main effects of type for any of the measures: First fixation duration, $\chi 2(1)=1.15$, p=0.28, gaze duration, $\chi 2(1)=0.22$, p=0.64, go-past duration, $\chi 2(1)=0.28$, p=0.59, and total time duration, $\chi 2(1)=0.13$, p=0.71.

In experiment 1, children's parafoveal pre-processing of orthographic and morphological information was examined to determine their differential effects on the processing of a complex target word. As expected, orthographic preview resulted in facilitatory effects for the processing of target words. When an orthographically overlapping preview was shown, the target word was fixated for less time (e.g., *market-marked*) than it was for the control-target pairing (e.g., *markol-marked*). Specifically, this effect was only borne out for the earlier eye-movement measures, first fixation and gaze duration, but not the later eye movement measures, go-past and total time durations. This suggests the notion that early measures reflect lexical/word access processes. For the morphologically related preview condition (e.g., *marker-marked*), no significant differences were found from the control condition. Moreover, no significant differences were found between the morphologically related preview condition and the orthographically related preview condition. It is possible that these findings are due to the focus children may have on simpler levels of information such as letters (represented in orthographic overlaps) as opposed to higher levels such as morphemes.

5.4 Experiment 2

In experiment 1 above, parafoveal preview effects of orthographically and morphologically related previews of children (i.e., developing readers) were examined. Orthographically related previews (e.g., *market*-marked) were found to facilitate complex target words significantly more than controls (e.g., *markol-marked*). The same effects were not found for morphologically related previews (e.g., *marker-marked*). Of interest is whether this pattern of effects may be attributed to the reading proficiency of the young readers, or whether it is generalisable to English readers in general, regardless of reading proficiency. Thus, the same issue was examined in proficient adult readers. It was expected that adults as proficient readers would use morphologically related information as a more efficient source of parafoveal information. Thus, it was hypothesised that adults would have a greater preview benefit for morphologically related than orthographically related previews. That is, compared to controls, morphologically related previews (and not orthographically related previews) should yield shorter looking times at the target complex words.

5.4.1 Experiment 2 Methodology

5.4.1.1 Participants

Participants and apparatus were identical to experiment 2 of Chapter 4. Indeed, the sentences for the current experiment served as filler items for Experiment 2 of Chapter 4 (and vice versa) and were presented intermixed with one another. For ease of access, this is repeated here. Adult participants were staff and student volunteers, recruited from Coventry University through physical posters. Twenty-three adults participated. Of these, five were excluded due to educational disabilities (N=1), incomplete data (N=1), and technical issues with the eye-tracker (N=3). Eighteen adult participants remained for analysis (nine male, nine female). Their ages were between eighteen and sixty years and their mean age was 30.61 years (standard deviation=10.07). All of the adult participants were either studying for an undergraduate degree or possessed higher qualifications. Adult participants were each given a £5 love2shop voucher for their participation. Ethical approval was gained from the Health and Life Sciences Research Ethics Committee at Coventry University prior to recruitment and data collection.

Again, as for experiment 1 above, the boundary paradigm technique (McConkie & Rayner, 1975) was employed, and the display changes occurred within 10 ms of the eye crossing the boundary (programme adapted from Pagán et al., 2016).

5.4.1.2 Materials and Design

Both child and adult participants read the same stimuli, as described in experiment 1 above.

5.4.1.3 Apparatus

Adults used the same apparatus as described in experiment 1.

5.4.1.4 Procedure

Adults were tested in a quiet room at Coventry University. Adults completed the TOWRE-2. Following this they completed the experimental eye-tracker task as described in experiment 1.

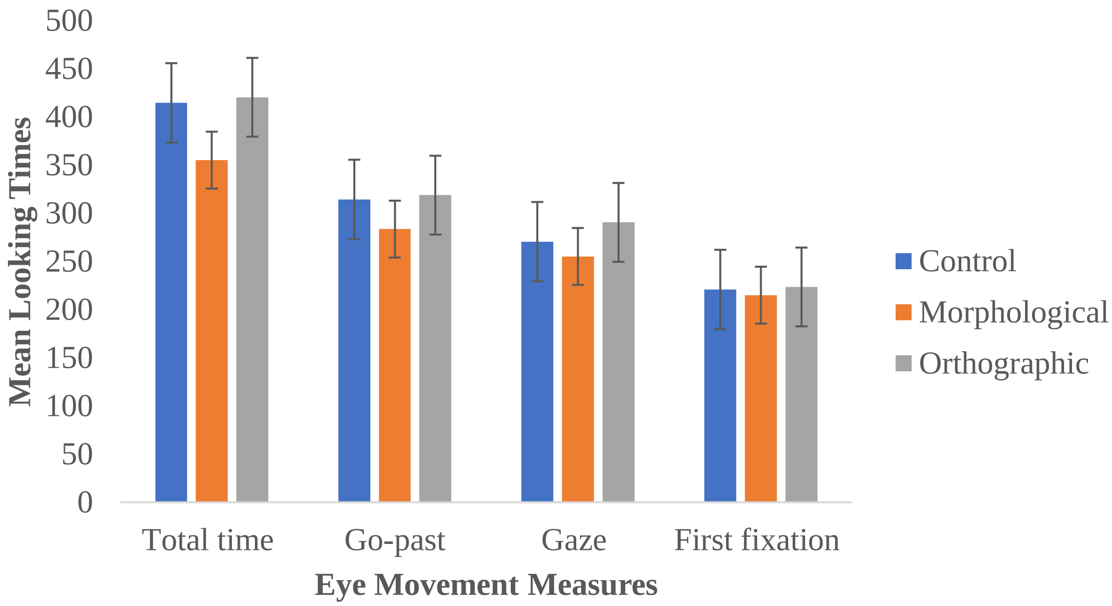
5.4.2 Experiment 2 Results and Discussion

Adults scored 100% on the comprehension questions. The ‘clean’ function in Data Viewer was used as described in Chapter 4. For this experiment, items were also removed when the target wasn’t fixated on the first pass, the boundary change occurred on words preceding the target, and the boundary change occurred more than 15 ms after the onset of the first fixation on target. This process resulted in 543/743 (73.08%) remaining items for analysis. Total time (the sum of all fixations on the word), go-past (the sum of all first-pass fixations until leaving the word to the right), gaze (the sum of all first-pass fixations until leaving the word) and first fixation duration measures were log transformed for analysis (Breadmore & Carroll, 2018; Pagán et al., 2016).

Figure 10 shows the mean looking times at the target morphologically complex words following morphological, orthographic and control parafoveal previews. Across all the eye movement measures, looking times were lowest in the morphological condition indicating that the morphological preview yielded the most benefit for target word processing.

Figure 10.

Adults' Mean Looking Times (ms) at the Target Morphologically Complex Words Following Control (Unrelated), Morphologically Related and Orthographically Related Previews across Total Time, Go-past, Gaze and First Fixation Durations



Analyses were carried out using linear mixed effects modelling, following the same procedures outlined in experiment 1. Full models included random intercepts for participants and items. The control words formed the baseline for the fixed factor of word type (control, orthographic, morphological). Regardless of the significance of the omnibus analyses, a priori comparisons between (a) control and orthographic, (b) control and morphological conditions and (c) orthographic and morphological were conducted. These contrasts are both theoretically and statistically justified (Schad et al., 2020). They are necessary to test the hypotheses and, moreover, including all three word type conditions in a single analysis limits variance and introduces overlap between groups (for example, the orthographic and morphological words were matched for word length and shared the same first few letters). LME summary statistics for the omnibus analyses are presented in Table 33.

Table 33.

Omnibus Adults Linear Mixed Effects Summary for Control, Morphological and Orthographic Word Types

	First fixation [b]			Gaze [a]			Go-past [a]			Total duration [a]		
Fixed effects	β	SE	t	β	SE	t	β	SE	t	β	SE	t
Intercept: Control word	222.23	11.61	19.41	271.60	16.65	16.05	314.88	19.93	15.80	413.55	45.23	9.14
Orthographic word type	4.46	11.96	0.37	19.27	13.80	1.13	5.18	18.04	0.29	10.89	33.88	0.32
Morphological word type	-7.56	12.02	-0.63	-16.37	14.05	-1.21	-31.83	18.31	-1.74	-52.93	34.44	-1.54

[a]Word type + (1|Participant) + (1|Item).
[b] Word type + (1|Participant)

For adults, omnibus analyses for main effect of type did reveal a significant effect for total time duration, $\chi2=6.23$, $p=0.04$. No significant effects were found in first fixation duration, $\chi2=1.40$, $p=0.50$, gaze duration, $\chi2=4.57$, $p=0.10$, or go-past duration, $\chi2=3.71$, $p=0.16$. The morphological word type yielded the shortest looking time, followed by the control word type and the orthographic word type. To understand which conditions differed significantly, a priori analyses compared each pair of conditions.

Turning to the adult comparison analyses, again orthographic word type was compared with control word type. No significant main effects were found for first fixation duration, $\chi2$ $(1)=0.85$, $p=0.36$, gaze duration, $\chi2$ $(1)=1.22$, $p=0.27$, go-past duration, $\chi2=0.03$, $p=0.86$, and total time duration, $\chi2(1)=0.64$, $p=0.43$.

When comparing the control word type with morphological word type only, no significant main effects were found for first fixation duration, $\chi2$ $(1) =0.01$, $p=0.90$, gaze duration, $\chi2$ $(1) =1.04$, $p=0.31$, go-past duration, $\chi2$ $(1) =3.04$, $p=0.08$ or total time duration, $\chi2$ $(1) =2.93$, $p=0.09$.

When comparing the morphological word type with orthographic word type only, significant main effects were found for gaze duration, $\chi2$ $(1)=4.55$, $p=0.03$, and total time duration, $\chi2$ $(1) =4.36$, $p=0.04$. There were no significant main effects of type for first fixation duration, $\chi2$ $(1) =1.46$, $p=0.23$ or go-past duration, $\chi2$ $(1)=3.07$, $p=0.08$.

In order to contextualise the findings from experiment 1 within a development perspective, the same experiment was carried out on adult participants. The results for adults, for the most part, align with the hypotheses made. The morphologically related condition (e.g., *marker-marked*) provided significantly more preview benefit than did the orthographically related condition (e.g., *market-marked*). That is, participants fixated less at the complex target word when the preview word was morphologically related than when it was orthographically related. The other two comparisons were found to not be significant.

5.5 General Discussion

The aim of the current study was to investigate the effects of different types of parafoveal previews (control, orthographic and morphological) on the processing of morphologically complex words. Moreover, this issue was examined in both adults (experiment 2) and children (experiment 2) in order to elucidate any developmental changes to the pattern of results.

As expected, for child participants, orthographic preview resulted in facilitatory effects for the processing of target words compared to control. Conversely and unexpectedly, morphological preview did not yield significantly more benefit that the control for children. Of note, the orthographic preview did not yield significantly more benefit than the morphological preview either. These findings suggest that children process orthographic overlap to a greater extent than morphological overlap in priming morphologically complex words. Children's sensitivity to affixes increases with reading skill (Hasenäcker et al., 2020). Peculiar though is that in the current experiment both the morphological (e.g., *marker-marked*) and the orthographic condition (*marker-market*) contained the same amount of orthographic overlap. Indeed, the morphological condition provided an added layer of information through the semantic link component. Beyersmann et al., (2012) found that Year 3 children (mean age: 8.1 years) and Year 5 children (mean age: 10.1 years) produced significant priming for truly suffixed primes (e.g., *golden–GOLD* vs. *frosty–GOLD*), but not for pseudosuffixed primes (*mother–MOTH* vs. *greedy–MOTH*) or nonsuffixed primes (spinach–SPIN vs. magical–SPIN). Thus, it is unexpected that the children (unlike adults) in the current study did not produce a parafoveal benefit for morphologically related preview words. However, several explanations are possible.

The children that participated in this study spanned a wide age range from seven to twelve years old. Importantly, seven of the children were at the low end of this range at 7-years-old. For example, Rosa and Nunes (2008) examined priming effects for morphological relatives on the spelling of different age groups of Portugese-speaking children. Although, 6-and 7-year-old children showed no evidence of morphologically related priming, 8-and 9-year-old children did. In the study by Beyersmann et al., (2012) discussed above, the youngest children showed marginally significant inhibition of pseudoaffixed priming. Perhaps this trend carries on to a greater extent for even younger children (as in this study), whereby even truly affixed priming may lead to some level of inhibition or a cancelling out of effects.

A significant difference also is that whereas the target word in Beyersmann et al., (2012) was a stem from the same morphologically complex prime (e.g., *golden-GOLD*), in this study, both the preview and the target were different morphologically complex words (e.g., *marker-marked*). Thus, in a similar way to the inhibition found in the pseudoaffixed condition of Beyersmann et al., (2012), the differences in affixes in this study may have caused some lexical interference for the younger participants.

Finally, it is worth noting that this seemingly unusual finding has been found previously. Quémart et al., (2017) investigated the differential roles of sematic and form relatedness in prime-target pairs. In their study, prime-target pairs varied in semantic similarity with the following prime-target pair conditions: low similarity (e.g., *belly-bell*), moderate similarity (e.g., *lately-late*), high similarity (e.g., *boldly-bold*), form only (e.g., *spinach-spin*) and semantics only (e.g., *garbage-trash*). Looking at the priming effects patterns reveal similarities as well as differences between the two age groups. For both age groups, the high similarity condition resulted in the largest priming effect. Yet, interestingly, this pattern diverged in other conditions.

For grade 5 children (mean age 10;11), the low semantic condition (e.g., *belly-bell*) had a higher priming effect (56 ms) than the form only condition (e.g., *spinach-spin*; 21 ms). This is expected as although both word pairs have comparable form relatedness, the low semantic condition contributes added semantic value. Yet, for grade 3 children (mean age 8;11), the form only condition yielded a higher priming effect (47 ms) than did the low semantic condition (27 ms). It is worth noting that all of the low semantic primes contained pseudo affixes (e.g., *bell-y*). Again, despite the added semantic and morphological (structure) components provided by the low similarity condition, and the same level of orthographic overlap, the form only condition yielded higher priming effects than did the low semantic condition. Moreover, this pattern was only reflected in the younger age group.

Some clues as to why this pattern emerges may be found in the time course found in the current study. In line with my hypotheses, a main effect of condition type (e.g., morphological relative, orthographic relative and control) was found only for the earliest eye-movement measure, first fixation duration. Similarly, comparing the orthographic preview condition with the control, there were significant main effects for the two earlier measures only (first fixation and gaze duration). That is, the orthographic condition provided a preview benefit at an early stage of the target word processing. This suggests that the facilitatory effects of the orthographically related condition were greatest at the earliest time point of target word processing. This may correspond to the swifter pre-processing of orthographically related previews as compared to higher level information such as morphology or semantics (Séverine Casalis et al., 2009). Future research might tackle this issue by isolating semantic and orthographic overlaps in morphologically complex words using the boundary paradigm.

Turning to the adult participants in experiment 2, results showed a different pattern than found in experiment 1. The morphologically related preview yielded significantly more benefit than the orthographically related preview in processing the target words. Surprisingly, the control condition yielded more benefit that the orthographically related condition. Although this was not significant, the trend is unexpected because the orthographic condition contained a real word which was orthographically related to the target.

There are two convincing explanations as to why the morphologically related preview was superior to its orthographic counterpart in facilitating target complex word processing. At every stage of the word identification pathway, the morphologically related preview provides the proficient reader with additional support for word identification processes (Levesque et al., 2020). Firstly, at the input level, morphological decoding involves parsing of letter-sound mappings according to morphemes (Levesque et al., 2020). Access to these larger linguistic units or 'chunks' is more efficient than to the letters involved in smaller orthographic units, which in turn speeds processing (Ehri, 2005).

Secondly, morphological processing is underlined by morpho-orthographic and morpho-semantic systems (Diependaele et al., 2005), affording a richer representation than can be provided by orthographic information alone. Certainly, findings from the current study suggests that both of these systems are key in the processing of morphologically complex words. Indeed, a surprising finding was that the orthographically related preview condition was less facilitatory than was the control condition in adults. This finding diverges from other studies that have found faciliatory effects for orthographic overlap (Ferrand & Grainger, 1993; Frisson et al., 2014).

Closer examination of the stimuli used in the current study compared with those used in other studies is revelatory. Adult priming studies that have found orthographic facilitation generally substitute single letters to generate form-related words. For example, in Frisson et al., (2014), the prime-target pairings only substituted one letter and did not share a root (e.g., *bear-gear*). In the current study, both the target and its orthographically related prime share the target's root *mark* (e.g., *market-marked*). Similarly, Drews and Zwitserlood (1995) found inhibitory effects for orthographic conditions which closely resembled their morphological conditions. The orthographic condition consisted of the target and additional letters resulting in a real word. Crucially, the target and its orthographic relative share a meaningful lexeme but are not semantically related. This lack of semantic link between the orthographically related preview and the target word may have caused dissonance which led to an inhibitory trend due to longer fixation on the target word (Hyönä & Bertram, 2004).

Inspection of the time-course of effects support this notion. Main effect analysis of condition type revealed a significant effect for the latest time measure only (total time duration). The morphological relative condition yielded significant preview benefits for two eye tracking measures, gaze duration and total time duration. Recall that gaze duration is the third latest eye-movement measure, while total time duration is the latest eye movement measure.

At first, this pattern seems strange. However, consider the notion that adult morphological processing combines both morpho-orthographic and morpho-semantic systems. In this scenario, earlier processing begins with orthographic information while later processing incorporates semantic information (Rastle & Davis, 2008). Indeed Casalis et al., (2009) found priming effects in orthographically related primes at the shortest prime duration, but priming effects in morphologically related primes at both the shortest and the longer prime durations. Thus, in the current study, it is possible that morph-orthographic processing corresponds to effects found at the earlier eye-movement measure, gaze duration, while morpho-semantic processing corresponds to effects found at the later eye-movement measure, total time duration. This is of course, speculative, and further research dissecting the time course of morpho-orthographic and morpho-semantic systems using the boundary paradigm would be ideal.

5.5.1 Limitations and Future Directions

In terms of limitations, due to the lack of inclusion of an identity prime condition (e.g., *marked-marked*) or no prime, we are unable to assess whether effects found are inhibitory or faciliatory. Although, these types of comparisons were possible between the different conditions examined, they were not possible between the conditions examined and processing of the target words without morphological or orthographic previews. The child sample examined consisted of a wide range of ages from seven years old to twelve years old. The absence of a homogeneous age group precludes the ability to pinpoint an exact age for the effects found. Yet, the aim of the current study was not to examine effects of different age groups in children but to compare child readers to proficient adult readers. Thus, future studies could specifically investigate parafoveal pre-processing of orthographic and morphological information in different age groups of children. In order to further investigate morphological processing across development (as in Dawson et al., 2018), it might be useful to replicate the current study examining specific age groups of children (7-9 years old), younger adolescents (12-13 years old), older adolescents (16-17 years old) and adults. This might elucidate the point at which children are able to effectively process morphological information. Finally, if the sample size was larger, particularly for the adults, stronger effects might have been found for some of the analyses.

5.5.2 Conclusions

The current study was the first to examine parafoveal processing of suffixed words using the boundary paradigm in adults and children. A certainty that has arisen from my findings is that adult and child readers process parafoveal orthographic and morphological previews differently. While children preferentially attend to orthographic information in facilitating complex word processing, adults conversely attend to morphological information. This difference appears to be driven by the developing reader's initial reliance on orthographic codes for reading. Whilst both orthographic and morphological development begin in the early school years, the latter has a much longer developmental trajectory or tail (Berninger et al., 2010). Indeed, as children learn to read they are gradually exposed to texts that are increasingly dense with morphologically complex words, and those children with poorer literacy skills tend to also possess less morphological knowledge (Nagy et al., 2014). Therefore, differences in reading proficiency may be reflected by the extent to which a reader is able to incorporate morphological knowledge. For example, Dawson et al., (2018) found key differences between adults and children's processing of morphologically structured letter strings. Specifically, during the adolescent stage, children developed automatized tacit morphological knowledge which allowed them to process morphologically structured nonwords more efficiently. Similarly, in the current study, beginner readers focused on orthographic information whilst showing less competence in assimilating morphological information. Proficient readers, on the other hand, used morphological and not orthographic preview information to facilitate the processing of multimorphemic target words.

6 Discussion

The aim of the current thesis was to assess the development of morphology from oral language in beginner readers to reading in intermediate, and proficient readers. In order to examine this broad issue, several different levels of readers were assessed using both cross-sectional and longitudinal designs: Adults, intermediate readers and beginner readers. In the sections that follow, I will report a summary of the main findings, followed by theoretical and practical implications of these findings, and finally possible limitations and future research.

6.1 Summary of Experimental Findings

6.1.1 Chapter 2

The current thesis commenced by examining the origins of morphological development. Thus, the aim was to assess morphological awareness in the oral language of very young readers. In chapter two, a novel dynamic assessment task was specifically created to capture morphological awareness in young beginner readers. The aim of the chapter was two-fold: experiment 1 sought to refine the task whilst concurrently using it to examine the morphological awareness of 50 children between the ages of three- and ten-years-old. This resulted in the final dynamic assessment of morphological awareness, which was a sentence completion production task containing six increasingly helpful prompts.

The aim of experiment 2 was to assess the reliability and validity of the dynamic awareness task for the target age range of 4 to 6-year-olds. In the second section of the chapter, 40 children were tested. Analyses were split into two age groups in order to assess the suitability of the task for the target age range (4-5 years old). The younger group consisted of children at the target age range (4-5 years old) and the older group consisted of children above this age range (6-8 years old). The internal reliability of the task was found to be good at Cronbach's Alpha=.77. The task was found to correlate significantly with both vocabulary and phonological awareness, supporting its validity. Indeed, several other studies have found that morphological awareness is closely related to both phonological awareness (Carlisle & Nomanbhoy, 1993) and vocabulary (Sparks & Deacon, 2015). Of note, the dynamic task produced a wide range of scores for the target age group, providing richer data than did the static results.

6.1.2 Chapter 3

Since the results supported the validity and reliability of the Dynamic Assessment of Morphological Awareness task, it was used in a main study in Chapter 3. In chapter 3, 40 children were examined longitudinally at Reception (4-5 years old) and then a year later in Year 1 (5-6 years old). At times 1 (Reception) and 2 (Year 1), the novel dynamic morphological awareness task as well as various literacy tasks were administered. Moreover, a novel phonological awareness task was created specifically to control for the phonological component of the morphological awareness task (i.e., segmentation, isolation and blending). It was hypothesised that morphological awareness at time 1 would be predictive of time 2 word reading (Kirby et al., 2012), reading comprehension (James et al., 2021) and spelling (Enderby et al., 2021).

The main finding in this chapter was that morphological awareness at time 1 was predictive of reading comprehension at time 2, when word reading (and not vocabulary) was controlled. On the other hand, morphological awareness at time 1 was predictive of spelling at time 2, when vocabulary (and not word reading) was controlled. Examining concurrent relationships at time 2 between the prompt 1 score (knowledge of morphological rules) and literacy skills revealed significant relationships between morphological awareness and spelling (*r*=.64, p<.001), word reading (r=.56, p<.001) and reading comprehension (r=.52, p=.001). The results suggest that morphological awareness in language is linked to literacy skills.

6.1.3 Chapter 4

A key question then was how the awareness of morphological structure might aid in reading morphologically complex words. In chapters 4 and 5, the developmental progression of morphological processing during reading was investigated in 25 children (7-12 years old) and 18 adults. Older children were assessed in chapters 4 and 5 (than in chapters 2 and 3) so that they possessed the literacy skills necessary to complete the reading tasks.

In chapter 4, surface and base frequencies of morphologically complex words were manipulated in order to assess the decomposition process in complex words. Participants read four different sets of morphologically complex words embedded within sentences while their eye-movements were recorded. The four sets were: High base and high surface frequency (e.g., *dangerous*), high base and low surface frequency (e.g., *purposeful*), low base and low surface frequency (e.g., *cowardly*) and low base and high surface frequency (e.g., *political*). Moreover, using the eye-tracker allowed for the temporal aspect of this process to also be examined by exploring the pattern of results across different eye movement measures.

For children, results showed surface frequency effects for all of the eye-movement measures except the earliest – first fixation duration. A base frequency effect was found for go-past duration. For adults, surface frequency effects were found for all the measures except the latest, total time duration. No base frequency effects were found for any of the eye-movement measures. For both age groups, a significant interaction between surface and base frequency was not found.

6.1.4 Chapter 5

Finally, for chapter 5, processing of morphologically complex words was further explored by examining the pre-processing of morphologically related prompts, orthographically related prompts and unrelated non-word controls. In this design, the boundary paradigm was used in a novel way to assess the parafoveal preview effects of morphological and orthographic information during sentence reading.

For children, findings revealed faciliatory effects from the orthographically related condition when compared to the control condition for the earlier eye-movement measures, first fixation and gaze durations. However no significant differences were found between the control and the morphologically related condition or between the morphologically related and orthographically related conditions. Conversely, for adults, findings revealed faciliatory effects from the morphologically related condition when compared to the orthographic condition for gaze and total time durations. In the following section, I will discuss findings from each experimental chapter in the context of their contributions to theory.

6.2 Theoretical Implications

6.2.1 Morphological Awareness can be Assessed in Beginner Readers

The first research question of this thesis was whether a valid and reliable assessment of oral morphological awareness could be created for young learners (i.e., 4-5-years old). Very few studies have sought to assess morphological awareness in such young learners, yet findings suggest that children from 4-years old do possess morphological awareness (e.g., Berko, 1958). Further, since morphological knowledge is multidimensional in its nature (Goodwin et al., 2017), different tasks may tap unique aspects of morphological awareness. For example, production tasks which are more likely to tap metalinguistic knowledge have been found to be more difficult for young children than judgement tasks which tap epilinguistic knowledge (Carlisle & Nomanbhoy, 1993). This has perhaps led to the notion that any evidence of morphological ability in young children is due to overlapping phonological skill and not true morphological awareness (Deacon & Kirby, 2004). Some researchers argue that those dimensions of morphology which are demonstrative of more conscious awareness may be inaccessible to young children (Carlisle & Feldman, 1995). Yet, studies have highlighted that task differences might contribute to findings of morphological awareness in younger readers (Wolter et al., 2009). For example, some tasks may require additional working memory load or even necessitate processing of complex instructions, reducing the cognitive resources available to young learners.

Thus, in chapter 2, a dynamic assessment of morphological awareness was constructed and piloted. Dynamic assessment was selected as a solution to the aforementioned issues that might arise from assessing metalinguistic morphological awareness in novice learners using traditional static methods. Results showed that the novel dynamic assessment is a valid and reliable measure of morphological awareness in the target age (i.e., 4-5 years old). A four-pronged approach was used to establish reliability and validity. Firstly, internal reliability was good with Cronbach's alpha at α=.77. Secondly, for the target age range, the task was significantly correlated with phonological awareness and vocabulary. Thirdly, for the older children, a ceiling effect was found as well as a lack of correlation between the novel task and standardised assessments. This suggested developmental progression in the task from the target age group to older children. It also highlighted the suitability of the task for beginner readers. Finally, and notably, when the static portion of the task was correlated with these measures (i.e., the initial response given), results were not significant. This suggested that further unique variance may be attributed to the responses given in the prompts of the dynamic assessment.

The results from chapter 2 complements and strengthens other studies that have found dynamic assessment to be a valid and reliable tool in assessing morphological awareness in 11-12-year-olds (Larsen & Nippold, 2007), 8-9-year-olds (Wolter & Pike, 2015), 6-7-year-olds (Wolter et al., 2020) and 4-5-year-olds (Pike, 2013). Crucially, the task constructed in chapter 2 assessed a deeper and more explicit dimension of morphological awareness using a productive rather than a judgement task (Diamanti et al., 2018). Thus, the findings demonstrate that, even at this young age, children have metalinguistic morphological awareness skill.

6.2.2 Morphological Awareness in Oral Language Contributes to Reading Comprehension and Spelling Development

The second broader research question was: Is oral morphological awareness in the language of novice readers predictive of literacy skills a year later? Numerous studies have found that morphological awareness contributes to several literacy skills including word reading (Kirby et al., 2012), reading comprehension (Levesque et al., 2017; Tong et al., 2011) and spelling (Deacon et al., 2009; Manolitsis et al., 2019). Yet the current study was novel in examining this relationship in beginner readers with less potential for orthographic influence.

In chapter 3, the morphological awareness task at time 1 (4-5 years old) only contributed unique variance to reading comprehension at time 2, after controlling for phonological awareness and word reading. Conversely, morphological awareness task at time 1 (4-5 years old) only contributed unique variance to spelling at time 2, after controlling for phonological awareness and vocabulary. Phonological awareness, conversely, contributed the most significant variance to word reading and spelling at time 2. These results including the lack of contribution to word reading might be considered surprising. However, bearing in mind the very young age of the participants involved in my study (i.e., 4-5 years old) provides some clarification.

Most of the studies that have examined the relationship between morphological awareness and literacy skills have involved older children than were assessed here (Deacon et al., 2009; Kirby et al., 2012; Tong et al., 2011). Indeed, in chapter 3, concurrent relationships between literacy and morphological awareness in the subsequent year revealed that morphological awareness contributed significantly to word reading, spelling and morphological awareness. The results may perhaps be due to the significant role of phonological awareness in word reading development at this early stage. This is especially salient when considering that phonics instruction dominates literacy instruction in the first year of school (Castles et al., 2018).

Next, I turn to the finding that morphological awareness task at time 1 (4-5 years old) only contributed unique variance to reading comprehension at time 2, after controlling for phonological awareness and word reading (and not vocabulary). In reading comprehension, text-level processes include synthesising grammatical, syntactic and semantic information in order to understand the text. In contrast, word-level processes involve lexical access of the word in isolation and might not rely as heavily on the multidimensional aspects of morphological awareness. At this age, morphological awareness may tap the word-level processes of reading comprehension and not the sentence-level processes. Younger children focus on accessing isolated words before tackling reading comprehension of longer texts. Thus, much of the variance attributed to vocabulary may also be linked to morphological awareness at this young age. Therefore, when vocabulary was entered as a predictor variable, morphological awareness no longer contributed significant variance to reading comprehension a year later. In the literature, Tong et al., (2011) found that morphological derivation was significantly worse for poor comprehenders than good comprehenders in Grade 5 but not in Grade 3. This highlights, perhaps, developmental changes in how morphology supports reading comprehension.

Finally, morphological awareness task at time 1 (4-5 years old) only contributed unique variance to spelling at time 2, after controlling for phonological awareness and vocabulary, but not word reading. This finding is not surprising. Morphological processes have been found to support children's spelling. Sensitivity to morphological regularities might support high-quality lexical representations for accurate spelling. Treiman and Cassar (1996) found that children as young as 6 use their knowledge of morphological relationships between words to spell. As it related to morphology in early oral language specifically, Deacon et al., (2009) found that morphology in oral language contributes to later spelling after controlling for several variables including verbal and nonverbal intelligence, rapid automatised naming, verbal short-term memory and phonological awareness. Notably, however, word reading was not included as a control. Indeed, spelling and reading are very closely related yet distinct domains of literacy (Levesque et al., 2020). Learning to read depends on the development of both skills. Moreover, the Morphological Pathways framework suggests that both skills rely on similar aspects of morphology (i.e., morphological decoding). It is expected then that the contribution of morphological awareness to spelling would not withstand the control for word reading.

The results found in chapter 3 offer a prospect for the role of morphological awareness in the simple view of reading (Hoover & Gough, 1990). At least at the very early stage of literacy studied here, oral morphological awareness was directly supportive of later reading comprehension, whilst phonological awareness was supportive of later word reading. Thus, for beginner readers, my results support the idea that word reading and reading comprehension vary in the extent to which they rely on different underlying skills.

However, in my study morphological awareness and concurrent word reading were closely linked at time 2. Depending on the type of task used, various dimensions of morphological awareness have been shown to support word reading, particularly in older children (e.g., Carlisle & Nomanbhoy, 1993). Therefore, as children get older and their literacy skills develop, morphological awareness might continue to contribute to reading comprehension directly through the linguistic system, and moreover indirectly through the orthographic system (Deacon et al., 2014). This lends support to the Morphological Pathways Framework which has postulated that morphological awareness contributes to reading comprehension via direct and indirect pathways (Levesque et al., 2020). My results suggest that the multidimensionality of morphological awareness increases in concert with children's literacy skills.

Overall, the results found are consistent with previous findings. For example, Carlisle and Feldman (1995) found that a sentence completion production task assessing morphological awareness in 6-7-year-olds was more closely related to subsequent reading comprehension than phonological awareness or indeed a morphological awareness judgement task. Meanwhile, phonological awareness was most closely related to word analysis the following year. Thus, results from chapter 3 are in line with previous findings. Moreover, these findings are novel in that they highlight the developmental progression from oral morphological awareness in young beginner readers with minimal literacy to a year later after exposure to formal education.

6.2.3 Children's Base Frequency Effects Suggest Decomposition of Morphologically Complex Words

Whilst chapters 2 and 3 examined oral morphological awareness in beginner readers, in chapters 4 and 5 we turned to morphological processing in intermediate and proficient readers. For both chapters, I sought to investigate, broadly, how adults and children process morphologically complex words during reading.

Specifically, the third research question was: Do adults and children decompose morphologically complex words according to base and surface frequency? In chapter 4, whilst surface frequency effects were found for both adults and children, base frequency effects were only found for children. This suggests that children do use morphological knowledge to process morphologically complex words.

Several prior studies have shown base frequency effects for both children and adults (Carlisle & Stone, 2003; Deacon et al., 2011; Deacon & Francis, 2017). Deacon and Francis (2017) argued that repeated exposure to isolated base forms (as reflected in base frequency effects) encourages both child and adult sensitivity to morphological structure. Moreover, these effects withstand controls for neighbourhood size, surface frequency and family frequency (Deacon & Francis, 2017; Ford et al., 2010).

Base frequency effects were not found for adults, yet this might be expected as the target words were specifically aimed at developing readers. According to the Morphological Pathways Framework, this contrast between children and adults could be a sign that children are using morphological decomposition to access the lexical representation of the word, but adults are not (Levesque et al., 2020). Similarly, Blythe et al., (2009) found that adults did not replicate children's looking patterns due to the simplicity of the employed text. When reading more difficult text, adult readers generally display similar effects to children (Taft, 2004). Moreover, in the current study, surface frequency effects were found for both children and adults. The lack of finding for base frequency effects, whilst finding surface frequency effects suggest that decomposition was not necessary for the adults given the simplicity of the text.

Finally, my study extended previous findings of base and surface frequency effects in children and adults by using the eye-tracker to examine the time-course of these effects. Whilst adult surface frequency effects were found for the three earlier eye movement measures, child surface frequency effects were found for the three later eye movement measures. This finding is expected given, as discussed, the text would be easier for the adults to read than the children. Therefore, children should take longer to encode the same word than adults (Schroeder et al., 2015). Also, early measures tap word level processes while later measures tap integration within the sentence (Blythe & Joseph, 2011). Here, this may be reflected by children's effects for later eye-movement measures and adults' effects for earlier eye-movement measures.

Finally, it is worth highlighting that for the child participants, the only eye-movement measure to show base frequency effects was go-past duration. Recall that this eye-movement measure encapsulated all fixations on the target before the word was exited to the right. At the same time, the eye-movement measures before (gaze duration) and after go-past duration (total time duration) also showed significant effects for surface frequency. Perhaps this provides some insight into the time-course of children's decomposition of complex words. It seems that while information about surface frequency is accessed from early on in encoding and throughout word processing, information about base frequency is only accessed at an intermediary stage. That is, after refixations of previous words but before any reading of the rest of the sentence. Perhaps, this points to the idea that certain words need to be decomposed while others do not, and it seems likely that words are first accessed wholly before any decomposition takes place. This would support Ehri's (2005) consolidated phase whereby sight words are accessed from memory (reflected by surface frequency effects) and less familiar words are broken down into chunks such as morphemes (reflected by base frequency effects). It follows then that base frequency effects were not found for adults, due to a relative absence of unfamiliar words.

In conclusion, chapter 4 showed surface frequency effects for both children and adults, whilst children also showed base frequency effects. This is perhaps due to differences in cognitive ability between adults and children vis-a-vis the relative text difficulty. Base frequency effects found for children suggest that they use decomposition processes to access morphologically complex words.

6.2.4 Adults Extract Morphological Information Parafoveally and Children Extract Orthographic Information Parafoveally

The final research question was: Are there developmental differences in adults' and children's extraction of morphological and orthographic information from the parafovea? Findings from chapter 5 revealed that adults extracted morphological information while children extracted orthographic information. These findings were anticipated. The morphological preview involved a semantic and orthographic overlap while the orthographic preview only provided a visual overlap. Thus, the adults' ability to assimilate morphological information is perhaps driven by differences in linguistic processing skills (Schroeder et al., 2015).

These findings support several theories on reding development. Specifically, skilled readers may attend more to larger chunks of information such as morphemes whilst children grapple with smaller orthographic codes (Ehri, 2005). This interpretation also supports the notion that less skilled readers access information at smaller grain sizes whilst more skilled readers access information at larger grain sizes (Goswami & Ziegler, 2006).

Looking at the time-course of effects from the adults and children provides further support for these assertions. Generally, orthographic previews benefits occur earlier on in processing whilst morphological preview benefits occur later on in processing (Feldman, 2000). The children's orthographic preview benefits were found in the earliest eye-movement measures, first fixation and gaze durations. Presumably, this reflects early, and quick processing based primarily on visual features that would be reflected by sensitivity to orthographic codes. It also suggests that children did not or could not make use of higher-level information such as semantics. In contrast, the adults' morphological preview benefits were found in the middle measure (gaze duration) and the latest measure (total time duration). This suggests that processing was based on morphological information which, in and of itself, encompasses aspects of both semantics and orthography.

Finally, the distinction between findings from chapters 4 and 5 warrants discussion. Although, there was evidence of morphological decomposition in children in chapter 4, in chapter 5 it became clear that these children didn't use morphological processes. This highlights the notion that morphological processing (like morphological awareness) is multidimensional and that different morphological processes do not develop simultaneously; some processes take longer than others (Levesque et al., 2020). In this case, foveal processing of morphologically complex words precedes the development of parafoveal processing of morphologically complex words. Although input is received from both parafoveal and foveal detectors, priority is given to allocating visual attention to the word being directly processed (i.e., foveally) (Angele et al., 2013). Thus, the findings from chapter 5 suggest that the intermediate reader does not have the requisite reading skill to parafoveally access optimal chunks of information (i.e., morphemes), resulting in orthographic effects for children and morphological effects for adults.

6.2.5 Overall Theoretical Implications

In the current thesis, morphological awareness (chapters 2 and 3) and morphological processing (chapters 4 and 5) were examined separately, particularly in relation to literacy development. Whilst morphological awareness has been described as a metalinguistic ability (Apel et al., 2012; Carlisle & Feldman, 1995), morphological processing is the actual identification of words based on morphological structure (Amenta & Crepaldi, 2012). In the current thesis, one common conclusion that arose from examining both of these distinct morphological concepts is the multidimensionality of morphology. Regarding development particularly, children seem to access different aspects of morphological knowledge at different stages of cognitive and literacy development. Indeed it is known that morphological awareness develops across time (Apel et al., 2013b) but due to its multidimensionality, the mechanism underlying its development is less clear.

At the onset of this thesis, it was hypothesised that morphological awareness in beginner readers (4-5-year-olds) would contribute to word reading, spelling and reading comprehension. The findings reported here support the two distinct word-level processes of the MPF, morphological analysis and morphological decoding. Morphological analysis which operates at the level of word meaning (morpho-semantics) is necessary for word-level comprehension. Here, morphological awareness contributed to reading comprehension when word reading, and phonological awareness were controlled but not when vocabulary was controlled. Thus, it appears that at this age, morphological awareness at the word-level, perhaps through morphological analysis is key for reading comprehension (Levesque et al., 2017). Morphological decoding which operates at the level of word form (morpho-orthographic) is necessary for word reading and spelling. In the current study, morphological awareness contributed to spelling when vocabulary and phonological awareness were controlled but not when word reading was controlled. Thus, here it appears that morphological awareness supported spelling development, perhaps through morphological decoding.

That morphology supports literacy development through multifaceted sources of information (e.g., morpho-semantic and morpho-orthographic), would highlight its value beyond a larger grain size. In terms of morphological processing, an unexpected result was that for intermediate readers, orthographic information facilitated the processing of morphologically complex words, whereas for adults, morphological information facilitated the processing of morphologically complex words. It would appear that attention to the morphological features of words increases with age.

It must be noted that morphological analysis and morphological decoding were not explicitly tested in the current thesis. It can only be surmised on the basis of the findings that these processes were key. Thus, a key future avenue for research is to assess morphological awareness in the oral language of young readers as well as subsequent morphological analysis, morphological decoding and literacy skills. This line of examination would further clarify the role that early morphological awareness serves as a foundation for morphological analysis and decoding. It would also elucidate the developmental progression of the direct and indirect morphological pathways.

6.3 Practical Implications

This thesis has practical implications for children's education in three areas: Morphological awareness assessment, literacy acquisition, and reading of morphologically complex words.

6.3.1 Assessment of Morphological Awareness

Firstly, the dynamic assessment of morphological awareness has been shown to be a reliable and valid tool for measuring morphological awareness in beginner readers. This is striking because morphological awareness has been viewed as a metalinguistic skill which might not be measurable in younger children (Carlisle & Feldman, 1995). Findings from chapter 2 are in line with other studies which have found that dynamic assessment is useful for measuring morphological awareness (Apel et al., 2013a; Larsen & Nippold, 2007; Wolter et al., 2020).

Findings supported the use of the current task for measuring morphological awareness in even younger readers in their first year of school. In an applied setting, this assessment could be important in two ways. Firstly, scaffolding through prompts allows teachers and practitioners to measure not only static ability but also learning potential. Using dynamic assessments for assessment in the primary school classroom has encouraged open dialogue and the active participation of more students (Davin, 2013). The task is particularly suited for younger children due to support and further instructions in the content of the prompts.

Secondly, whilst intervention programmes are essential for improving the academic performance of children in primary schools, they can be time consuming (Noell et al., 1997). The dynamic assessment of morphological awareness was created so that each prompt tapped a different skill. Thus, in a practical setting the diagnostic value of the prompts might provide some insight into the areas in which a student is failing. Where a larger-scale intervention might not be feasible, the assessment may be ideal to identify which specific skills each child is lacking, therefore allowing more targeted and time-efficient interventions to be implemented.

6.3.2 Literacy Acquisition

Next, morphological awareness in oral language was found to contribute to reading comprehension and spelling a year later. Reading comprehension is an essential aspect of skilled reading (Hoover & Gough, 1990). Indeed, a child cannot competently read text using decoding alone (Castles et al., 2018). James et al., (2021) found that morphological awareness contributes to reading comprehension in children from the age of six. They suggested that morphological awareness should be taught from the earliest stages of education. Moreover, previous studies have also found that morphological awareness in early oral language contributes to spelling, after controlling for several variables (Deacon et al., 2009).

In the current thesis these findings are extended by examining the diachronic relationship between morphological awareness, reading comprehension and spelling. Moreover, in order to control for the effects of phonological awareness in my task specifically, an analogous phonological task was created. Even after controlling for phonological awareness, morphological awareness contributed significantly to reading comprehension and spelling a year later. Prior findings are extended by examining children as young as 4.

Findings from chapter 3 support the notion that from the very earliest stage of formal education, the instruction of morphological awareness would support later reading comprehension and spelling. Further, the findings suggest that as children's literacy skills develop, morphological awareness starts to support word reading. Thus, I propose that morphological awareness is useful for children from the beginning of school and continues to support literacy skills, at least in the first two years of school.

6.3.3 Reading of Morphologically Complex Words

In chapter 4, a base frequency effect was found for the children but not for the adults. This suggests that when the children were unable to read a less familiar complex word, they resorted to decomposition. Indeed, sensitivity to the structure of morphologically complex words supports reading comprehension and reading (Carlisle, 2000). My study has important implications for teaching children to read new, unfamiliar words. Printed school English contains a substantial amount of less frequent words (Nagy & Anderson, 1982). Moreover, less frequent words are much more likely to be morphologically complex than more frequent words.

Educationally then, it seems that teaching children about the morphemic structure of words might help them as they increasingly encounter unfamiliar complex words. If a child is unable to decode a morphologically complex word by sight (as reflected by surface frequency effects), they can rely on their knowledge of its morphemic components (Anglin et al., 1993).

Finally, in chapter 5, children were found to attend to orthographic information whilst skilled adult readers attended to morphological information. Thus, my findings suggest that skilled and intermediate readers adopt different parafoveal processing strategies. It seems intuitive that, in my study, the adult readers used the more effective strategy. This further reinforces the argument that a higher awareness of morphological structure is important for skilled reading. On the basis of my results, I suggest that children should be explicitly taught about the morphemic structure of words in order to improve complex word processing.

6.4 Limitations and Future Research

In the following section, possible limitations and recommendation for future research will be discussed. In the future, it would be worth using the task on pre-school children the year before formal education (i.e., 3-4-year-olds). By measuring morphological awareness in children without formal education, a purer measure of morphological awareness is achieved. That is, children at this age have not been exposed to phonological, literacy instruction which might affect their morphological knowledge. Thus, we can be more certain that the ability tested is due to morphological awareness and not underlying literacy skills from orthographic knowledge.

Turning to the studies on morphological processing, there were also some limitations. In chapter 4, base and surface frequency effects of children and adults were compared. The stimuli used were aimed at the children and therefore, the surface and base frequency levels were probably not representative for the adults. This is probably why base frequency effects were not found for adults. However, this was done in order to allow for direct comparison between adults on children using the same stimuli. In the future, the study could be replicated using target words which have been assessed for base and surface frequencies based on an adult frequency corpus.

In chapter 5, participants were presented with an orthographic preview benefit, a morphological preview benefit and a control. Unfortunately, a condition without the boundary change was not included. Thus, it was impossible to discern whether the effects found were faciliatory or inhibitory. Although it was still possible to compare the effects of each condition against each other, we cannot determine whether the previews provided facilitation or inhibition in terms of overall target word processing.

Throughout several of the studies, sample sizes may have been insufficient. In chapter 2, experiment 2, data was separated into younger and older participants further decreasing the sample size overall. In chapter 3, the completion rate for the morphological awareness task at time 1 was much lower than at time 2, decreasing the amount of available data. Finally, in chapters 4 and 5, the sample size was lower than other similar eye-tracking paradigm studies (e.g., Pagán et al., 2016) although comparable to others (e.g., Joseph et al., 2013; Mousikou &

Schroeder, 2019). These smaller sample sizes perhaps decreased the variability in the data. For example, dynamic morphological awareness scores in chapters 2 and 3 were negatively skewed. Also, due to the sample size in chapter 3, regressions were limited with regards to the number of variables included. Overall, the smaller sample sizes led to a decrease in statistical power whereby existing effects may have been missed or underestimated. Future research should replicate these studies with larger samples.

6.5 Conclusions

This thesis makes an important contribution to knowledge on morphological development in four areas. Firstly, a novel dynamic assessment of morphological awareness was found to be a reliable and valid test for children as young as 5. Secondly, at the earliest stage of education, morphological awareness was supportive of reading comprehension a year later, highlighting its key role in early literacy development. Thirdly, base frequency effects were found in children but not adults, pointing to a key role for decomposition in unfamiliar word reading processes. Finally, skilled adult readers showed a morphological preview benefit while intermediate child readers did not, and only showed an orthographic preview benefit. The results found suggest that a.) children as young as 5 do possess morphological awareness, and it is measurable b.) morphological awareness in oral language at this young age contributes to reading comprehension and and may play a causal role in the development of reading comprehension c.) the morphological structure of words supports skilled reading through multiple processes, which do not develop in unison. Overall, the findings suggest that due to its multidimensionality, morphological development changes over the course of a child's education, supporting different skills. Crucially though, morphological knowledge was found to be important for various aspects of literacy processes and development from the first year of school into adulthood.

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Appendix A

SUBT-LEX Cbeebies Word Frequencies and Word Lengths for the Target and Scaffold Words.

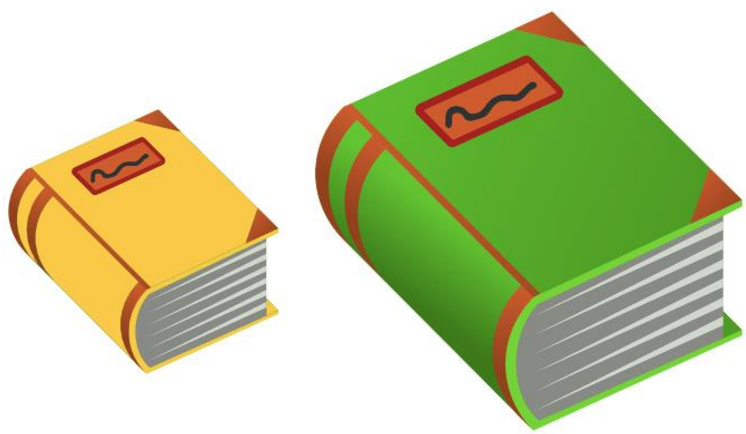
Target word	Target word length (WL) and word frequency (WF)	Scaffold word	Scaffold word length (WL) and word frequency (WF)
The word is count. They can count. Yesterday, they ***counted***.	7 (WL); 3.93 (WF)	PRACTICE	n/a
The word is listen. They like to listen. See how well they are ***listening***.	9 (WL); 4.66 (WF)	PRACTICE	n/a
The word is nose. This is my nose. These are their ***noses***.	5 (WL); 3.75 (WF)	The word is house. This is my house. These are their ***houses***.	6 (WL); 4.88 (WF)
The word is jump. This girl likes to jump. Last week, she ***jumped***.	6 (WL); 4.27 (WF)	The word is dance. This boy likes to dance. Last week, look how much he ***danced***.	6 (WL); 3.88 (WF)
The word is cry. Babies cry. Yesterday, this baby ***cried***.	5 (WL); 4.02 (WF)	The word is try. At school, children try. Yesterday, this boy ***tried***.	5 (WL), 5.15 (WF)
The word is stop. The rain won't stop. I like it when the rain ***stops***.	5 (WL); 4.37 (WF)	The word is play. My friend won't play. I like it when my friend ***plays***.	5 (WL); 4.64 (WF)
The word is brush. This boy does a lot of brushing. Look how he ***brushes***.	7 (WL); 3.46 (WF)	The word is push. Mum does a lot of pushing. Look how she ***pushes***.	6 (WL); 3.79 (WF)
The word is nice. This toy is nice. This toy is even ***nicer***.	5 (WL); 3.93 (WF)	The word is big. This book is big. This book is even ***bigger***.	6 (WL); 5.02 (WF)
The word is small. This book is small. This book is the ***smallest***.	8 (WL); 4.06 (WF)	The word is new. This car is new. This car is the ***newest***.	6 (WL), 3.68 (WF)
The word is ankle. It went around her ankle. Then around both ***ankles***.	6 (WL); 3.48 (WF)	The word is hand. She held on with one hand. Then she held on with both ***hands***.	5 (WL); 5.25 (WF)
The word is help. Doris likes to help people. Doris is a ***helper***.	6 (WL); 3.22 (WF)	The word is think. Mary likes to think. Mary is a ***thinker***.	7 (WL); 3.18 (WF)
The word is carry. He could not carry anything else. See how much he was ***carrying***.	8 (WL); 4.53 (WF)	The word is walk. He could not walk anymore. See how much he was ***walking***.	7 (WL); 4.92 (WF)
The word is lady. This badge belongs to the lady. The badge is the ***lady's***.	4 (WL); 5.15 (WF)	The word is teacher. This pen belongs to the teacher. The pen is the ***teacher's***.	7 (WL); 4.68 (WF)
The word is glow. Starts glow in the sky. Last night they ***glowed***.	6 (WL); 2.47 (WF)	The word is roar. Lions roar. Last night they ***roared***.	6 (WL); 3.05 (WF)

Target word	Target word length (WL) and word frequency (WF)	Scaffold word	Scaffold word length (WL) and word frequency (WF)
The word is waddle. The ducks waddle through the field. Look how that duck ***waddles***.	7 (WL); 1.97 (WF)	The word is climb. The monkeys climb the tree. Look how that monkey ***climbs***.	6 (WL); 3.36 (WF)
The word is cat. This cat has a tail. This tail is the ***cat's***.	3 (WL); 4.83 (WF)	The word is dog. This dog has a bowl. The bowl is the ***dog's***.	3 (WL); 5.17 (WF)
The word is fetch. This dog likes to fetch. See all the things he ***fetches***.	7 (WL); 2.73 (WF)	The word is scratch. This cat likes to scratch. See all the things she ***scratches***.	9 (WL); 3.27 (WF)
The word is bushy. This fox has a bushy tail. That fox's tail is even ***bushier***.	7 (WL); 1.77 (WF)	The word is spotty. This fox has spotty skin. That frog's skin is even ***spottier***.	8 (WL); 1.17 (WF)
The word is dirt. Sam was covered in dirt. Sam looked ***dirty***.	5 (WL); 4.57 (WF)	The word is cloud. The sky was full of clouds. The sky was ***cloudy***.	6 (WL); 4.17 (WF)
The word is care. Mum said "Take care crossing the road. Be ***careful***."	7 (WL); 4.84 (WF)	The word is forget. This Mr. Man forgets a lot. Dad says "He is ***forgetful***".	9 (WL); 2.76 (WF)

Appendix B

Figure B1. *Supporting picture for the target item 'nicer'.*

Figure B2. *Supporting picture for the accompanying scaffold item 'bigger'.*



Appendix C

The Analagous Phonological Awareness Task

Instructions: ‘Now I would like you to put two alien words together to make a new word. Let’s practice two first.’

Stop rule: 5 in a row incorrect.

Nonword root	**Nonword affix**	**Nonword phonemes**	**Response**	**Score**
goomp	eb	gumpɛb		
mos	ase	moses		
Junt	ip	tʃʊntIp		
glay	b	gleb		
Zor	th	zɔ:θ		
pluth	es	plʊθes		
mayth	a	meθæ		
snov	ef	snovef		
engle	iv	ɛŋglIv		
piv	ur	pIvɜ:		
tevi	on	tɛvIan		
saib	isce	saɪbɪs		
craw	g	krɔːg		
rabbl	ig	ræblIg		
te	ch	tɛʧ		
bɛsh	ev	bɛʃɛv		

Nonword root	Nonword affix	Nonword phonemes	Response	Score
puchee	a	Pʌʧia		
bip	a	bIpa		
ti	suv	tIsʌv		

Appendix D

Table D1. *List of Morphologically Complex High Surface Frequency Words With Low or High Base Frequency Accompanied by Their CELEX Base Frequency and Surface Frequency (and Educator's World Frequency Guide Equivalents in Parentheses).*

	High base & high surface frequency words			Low base & high surface frequency words	
Target Word	Base frequency	Surface frequency	Target Word	Base frequency	Surface frequency
Addition	21 (70)	62 (100)	Available	3 (70)	138 (100)
Completely	90	114(79)	Computer	0	62 (79)
Dangerous	74 (107)	82 (73)	Equipment	0 (107)	75 (73)
Development	18	181 (126)	Especially	1	173 (126)
Directly	85 (69)	71 (97)	Eventually	7 (69)	88 (97)
Effective	156	66 (58)	Medical	1	77 (58)
Generally	258 (106)	93 (110)	Normal	7 (106)	92 (110)
Leader	43 (113)	68 (65)	Political	1 (113)	300 (65)

Table D2. *List of Morphologically Complex Low Surface Frequency Words With Low or High Base Frequency Accompanied by Their CELEX Base Frequency and Surface Frequency (and Educator's World Frequency Guide Equivalents in Parentheses).*

	High base & low surface frequency words			Low base & low surface frequency words	
Target Word	Base frequency	Surface frequency	Target Word	Base frequency	Surface frequency
Developer	18 (106)	2 (1)	Avidly	2 (0.78)	2 (0.33)
Dryness	82	1 (1)	Cohesiveness	2	0 (0.14)
Follower	22 (155)	2 (1)	Cowardly	5 (1)	3 (1)
Locally	248	11 (1)	Diligently	2	2 (1)
Purposeful	(144)	(1)	Dismissal	2 (1)	8 (1)
Serviceable	179	2 (0.74)	Impairment	0	1 (1)
Traveler	38 (107)	6 (1)	Mower	0 (0.95)	2 (3)
Wonderment	46 (116.6)	1 (0.54)	Offender	1 (0.93)	3 (1)

Appendix E

List of Morphologically Complex Words Embedded into Sentence Frames Across the Four Surface and Base Frequency Conditions. Target Words are the Fourth Word in Each Sentence.

High base, high surface	Low base, high surface	High base, low surface	Low base, low surface	Sentence frame
They took the leader to make the plans.	They took the computer to get it fixed.	They took the developer to see the land.	They took the offender to meet the judge.	They took the * to***
Coach wants the development to be very strong.	Coach wants the available to help with training.	Coach wants the follower to become a captain.	Coach wants the mower to cut the grass.	Coach wants the *to ***
He saw the addition that the builder made.	He saw the equipment that needs some oil.	He saw the traveller that he was hosting.	He saw the impairment that caused her limp.	He saw the * that ***
It will be effective from May this year.	It will be normal from Monday to Friday.	It will be dryness from the cold air.	It will be dismissal from the head office.	It will be * from ***
The man is dangerous in all tense situations.	The man is political in even friendly talks.	The man is purposeful in how he works.	The man is cowardly in his daily life.	The man is *in ***
Students are in generally to see the teacher.	Students are in eventually to learn after holidays.	Students are in wonderment to see the parrot talk.	Students are in cohesiveness to get good grades.	Students are in * to ***
The tools were completely and carefully checked today.	The tools were medical and used on patients.	The tools were serviceable and he kept them.	The tools were diligently and cautiously used yesterday.	The tools were * and ***
The athletes ran directly for the town hall.	The athletes ran especially for their loving fans.	The athletes ran locally for a great charity.	The athletes ran avidly for the last mile.	The athletes ran * for ***

Appendix F

List of Stimuli Words Embedded into Sentences Before and After the Boundary Change.

Word	Condition	Sentence before boundary	Sentence after boundary
Tricky	Target		
Tricked	Morphological	The test was tricked but Tom completed it.	The test was tricky but Tom completed it.
Trickle	Orthographic	The test was trickle but Dan finished it.	The test was tricky but Dan finished it.
Trickob	Control	The test was trickob but Will managed it.	The test was tricky but Will managed it.
Rocking	Target		
Rocked	Morphological	Sally was slowly rocked in the wooden chair.	Sally was slowly rocking in the wooden chair.
Rocket	Orthographic	Sally was slowly rocket in her pink cot.	Sally was slowly rocking in the pink cot.
Rockud	Control	Sally was slowly rockud in a brown hammock.	Sally was slowly rocking in the brown hammock.
Singing	Target		
Singer	Morphological	The birds were singer in the early morning.	The birds were singing in the early morning.
Single	Orthographic	The birds were single in a bird bath.	The birds were singing in a bird bath.
Singan	Control	The birds were singan in their little house.	The birds were singing in their little house.
Banning	Target		
Banned	Morphological	The town is banned bikes from the park.	The town is banning bikes from the park.
Banner	Orthographic	The town is banner bikes from the centre.	The town is banning bikes from the centre.
Bannol	Control	The town is bannol bikes from the pavement.	The town is banning bikes from the pavement.
Marker	Target		
Marked	Morphological	Tom used a marked to draw a picture.	Tom used a marker to draw a picture.
Market	Orthographic	Tom used a market to write his name.	Tom used a marker to write his name.
Markol	Control	Tom used a markol to make the card.	Tom used a marker to make the card.
Needing	Target		

Needed	Morphological	I will be needed the blue Math book.	I will be needing the blue Math book.
Word	Condition	Sentence before boundary	Sentence after boundary
Needle	Orthographic	I will be needle the paper and pen.	I will be needing the paper and pen.
Needat	Control	I will be needat the big text book.	I will be needing the big text book.
Harmful	Target		
Harming	Morphological	Plastic can be harming to our beautiful planet.	Plastic can be harmful to our beautiful planet.
Harmony	Orthographic	Plastic can be harmony to all water sources.	Plastic can be harmful to all water sources.
Harmloy	Control	Plastic can be harmloy to the clean town.	Plastic can be harmful to the clean town.
Cracks	Target		
Cracked	Morphological	There are many cracked in my favourite cup.	There are many cracks in my favourite cup.
Cracker	Orthographic	There are many cracker in his cereal bowl.	There are many cracks in his cereal bowl.
Crackot	Control	There are many crackot in her big jar.	There are many cracks in her big jar.
Mounted	Target		
Mounting	Morphological	The photo was mounting on the back wall.	The photo was mounted on the back wall.
Mountain	Orthographic	The photo was mountain on a white board.	The photo was mounted on a white board.
Mounteap	Control	The photo was mounteap on our kitchen door.	The photo was mounted on our kitchen door.
Being	Target		
Been	Morphological	The sisters are been kind with each other.	The sisters are being kind with each other.
Beet	Orthographic	The sisters are beet kind to their dog.	The sisters are being kind to their dog.
Beor	Control	The sisters are beor kind for my birthday.	The sisters are being kind for my birthday.